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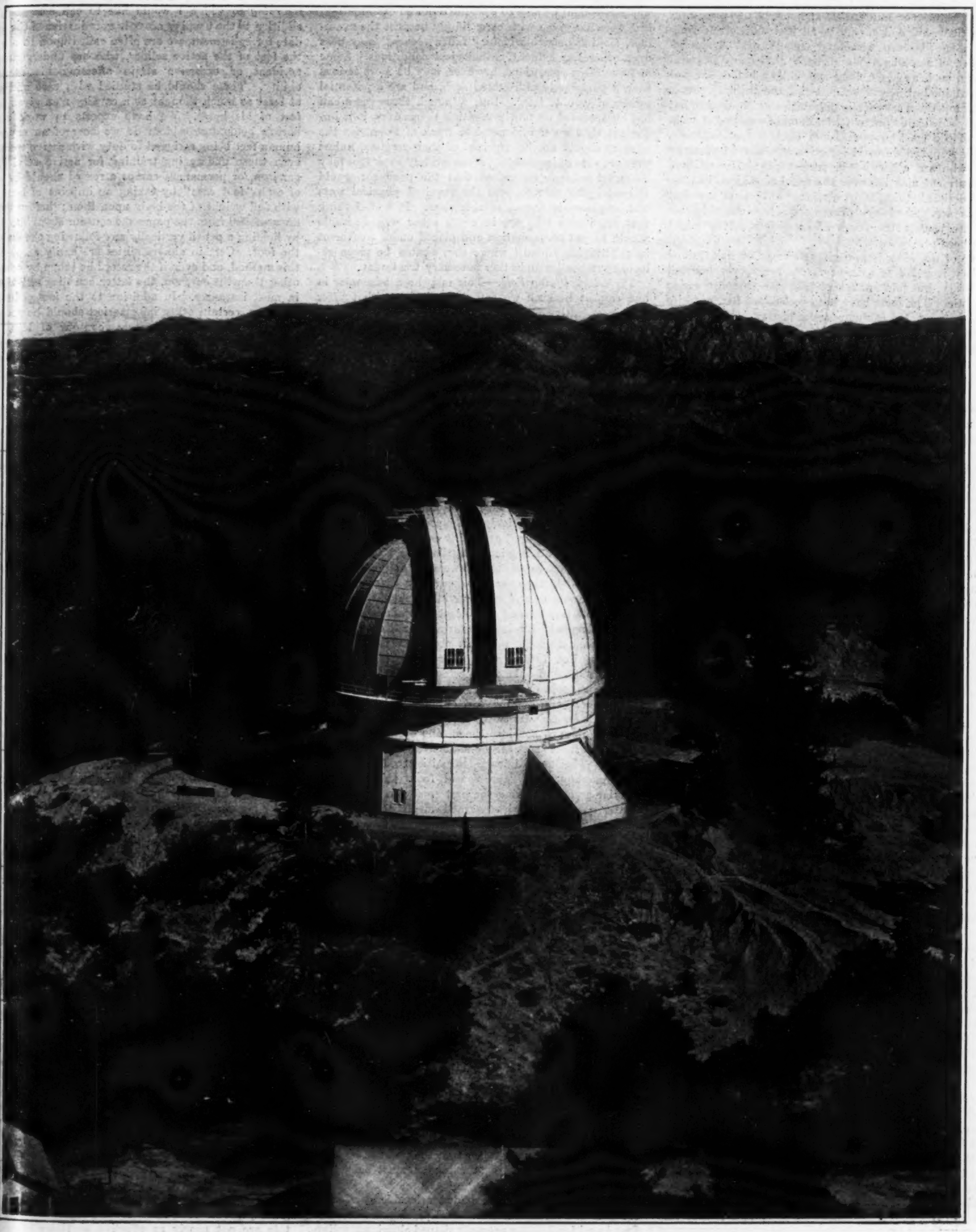

Dome that houses the 100-inch Telescope on Mt. Wilson

THE LARGEST "REFLECTING" TELESCOPE IN THE WORLD [See page 104]

# The Soldier's Foot*

## An Important Feature of an Effective Army

By Harold D. Corbusier, B.S., M.D.[1]

In order to produce an effective army, certain things are essential; a country must have physically fit men, munitions, subsistence and equipment; and all of these must be developed and maintained at their maximum. These requisites, except the man power, are capable of being produced by human skill and energy, but it requires more than skill and energy to fill the ranks of an army with men who can withstand the physical strain demanded of a soldier. We all know that many physical defects, such as heart, lung and kidney lesions are not preventable but may develop during the ordinary course of life, but there are certain disabilities which, though not usually considered preventable, should be classed as such. One of the most pronounced of these is *foot weakness*. This is responsible for the rejection from service of many men who are otherwise in perfect physical condition.

Treatment may improve abnormal conditions but the most desirable thing is prevention. Defects of the vital organs are not always preventable, but unserviceable feet are usually the result of conditions which might have been prevented.

One of the most important attributes of well-trained soldiery is *guarding efficiency*. No army ever hobbled to victory, but foot endurance has often turned the tide of battle. The facts have been recognized for centuries by the most noted commanders of history. Napoleon is reported to have said that the man who produced a proper foot gear for soldiers would do more than anyone else toward bringing about an efficient army. Marshal Saxe is credited with the remark that "the secret of war lies in the limbs of the soldier," and Wellington said, "a soldier is as good as his feet." Evidently foot troubles are not a new problem, although modern conditions of civilian life are undoubtedly responsible for the increase of such troubles. The present-day army is composed of picked men, whereas formerly the physical examination of recruits was unheard of, so the weak foot was not discovered until men were put to the strain of marching. Ever since civilization introduced shoes, the armies of the world have been hampered by tired and "foot-sore" soldiers.

The life led by most civilians does not demand maximum foot efficiency, owing to the fact that there are so many modes of transportation, and the leg and foot muscles are not given sufficient opportunity to develop. A man can not live many years with a heart, lung or kidney lesion without some manifestation of these conditions; however, one may pass a good many years of his life with feet which are considerably below normal without encountering any particular difficulty, because his feet have been able to perform the duty required by an inactive body. Even the man who is "on his feet all day" has not put his legs and pedal extremities to the severest test; that is, to such strain as is demanded by military service. We are, therefore, not always able to judge after the usual tests whether or not a man is really fit for field service. The supreme test arrives when the civilian has entered military service and is compelled to march at a fixed rate, in company with others, carrying a pack, and not being able to pick his way. Many men whose ability to march is questioned, assert that they have tramped through forests and mountains, carrying a pack and have been able to reach their destinations without much difficulty. Tramping by one's self, or in company with a few other sympathetic individuals, is quite possible for the man with only a partially efficient foot, because he can rest at any time and usually is able to select his footing; moreover, his rate of march is modified to suit his convenience and that of his just-a-little-tired feet.

In classifying the feet of prospective recruits from the standpoint of the examiner, we might place them in three classes: First, the acceptable; second, the doubtful; third, the disqualifying.

*The Acceptable Foot.*—If the applicant for enlistment is put through foot and leg tests without eliciting pain he can be passed by the examiner. Of course these tests must be severe and should consist in hopping as high as possible, backward and forward, on one foot at a time, landing on the toes; raising the body on the toes of one foot at a time; jumping from a chair, landing on the toes, each foot separately; walking on the heels; raising the body from a squatting position. A good many men who have some obliteration of the long arch of the foot and are said to be "flat footed" can pass these tests. These cases should be classed as acceptable if they also have well-developed muscles, freedom from deformities and free action of all joints.

*The Doubtful Foot.*—This class should not be accepted for enlistment, although they are frequently able to pass the examiner. In other words, a certain amount of foot weakness might be able to pass the required examination, if it were not given with care, simply because the examiner, looking particularly for "fallen arches," may pass over other less evident pathological conditions. Some of these other conditions, however, may be more serious than a moderately obliterated arch, and are a potential source of trouble later. But, although these cases can not be accepted on first presenting themselves, it is important that we should not lose track of them, for the country should not be deprived of their services, unless they are proved incurable. A moderately weak foot may be cured to such an extent that the possessor would ultimately be able to pass the required physical tests and be placed in the acceptable class. In fact, I think that applicants who are in every other way desirable should be put on probation and placed under treatment in a "training squad" where they should be given selected gymnastics and other necessary treatment.

*The Disqualifying Foot.*—This may be a misnomer in one respect because we can never be sure that after certain operative procedures the foot can not be made useful. However, what may be a useful foot for a civilian may be absolutely impossible as far as military service is concerned; this is a question of degree and each case should be considered separately. Included in this disqualifying class are the greatly everted feet with prominent scaphoids and obliterated long arches, the "monkey foot"; the "claw-toed" foot, with contracted tendons and phalanges articulating on the dorsal surface of the metatarsals, such cases usually having obliterated anterior arches and callosities under the distal ends of the metatarsals; the flaccid foot, with lax ligaments permitting the flattening and spreading of the bones; excessive hallux valgus often accompanied by obliteration of the long arch; excessively "high arches" and results of talipes; painful "spurs" and other exostoses; excessively ingrown nails and lapping toes; large and painful callosities and numerous corns; sweating and odoriferous feet. Although these are disqualifying defects, many of them are curable and such candidates should be placed on the probation list and after treatment admitted to the "training squad" for instruction and final observation. It may seem to some that this procedure is rather unnecessary, but I have been thoroughly impressed of late with cases of splendid specimens of manhood who have had the sole disqualifying defect in poor feet. Often this sort of man would make an excellent officer and such material is far too scarce.

I wish now to consider the means by which a great number of these cases can be made available for military service. The most difficult deformities to deal with are the "monkey foot," the flaccid foot, and depressed anterior arches. I think the best operation for the cure of the *everted foot* with marked displacement of the scaphoid, is one which was first brought to my attention by Dr. Robert E. Soule. This operation consists of making an ankylosis between the scaphoid and the astragalus with the extra support of a bone pin penetrating both bones at an angle of about 45 degrees, the foot then being inverted and placed in plaster of Paris, or an aluminum splint, shaped for the purpose. This operation usually produces a serviceable foot for the civilian, and I am inclined to believe that, in most cases, it would withstand the strain of military service. So far as I know there is no method which could be used to make the flaccid foot serviceable for military purposes, and therefore, such feet for the present must be definitely refused.

The extreme *depression* of the *anterior arch*, with the usual "claw-toes," is a difficult problem and the operations so far devised to remedy this deformity, such as resection of the distal ends of the metatarsals, are of doubtful value, from a military standpoint.

*Hallux valgus* should be treated radically by the resection of the distal end of the first metatarsal or by the removal of a V-shaped wedge just posterior to the articular surface. In these cases the extensor tendon should be replaced with care in order that the pull can be in the original direction; that is, the tendon must be parallel with the replaced great toe.

Simple *clawed toes* can be made serviceable by a lengthening of the extensor tendons and placing the toes in a flexed position held by properly shaped aluminum splints. By the use of such splints a good many deformed toes can be returned to normal without operation. *Hammer toes* can be corrected by operation, but if there is a great deal of bony deformity the toe should be amputated. "*Spurs*" and other *exostoses* and *ingrowing nails* can usually be cured by the customary operations.

There are a few points in *methods of examination* and *recording* to which I would like to call attention. In addition to the usual gymnastic examination of the candidate for enlistment, we are often called upon to examine the feet of the active solider, who has undergone some accident or excessive strain affecting his marching ability. These should be studied with care and given at least as much thought as a cavalry man gives to the feet of his horse. We have experts to work on the horse's hoofs, but seldom do we hear of an expert on human feet being assigned to duty with active troops, or even those undergoing training for active service. In garrison, or permanent camps a record should be made of each "foot case" by taking an imprint of both feet with full weight of the body upon them; before the feet are removed from the paper the contour should be drawn by holding a pencil vertically and following the curves of the foot. Certain abnormalities are easily recorded by this method, and even if the record be taken by some one other than the surgeon, the latter can diagnose the case in most instances. In addition to the foot prints and contours, certain other information should be recorded, such as age, weight, posture, contour of legs, pain, rigidity or laxity of muscles; location and extent of callosities; size and width of shoe worn. This method, with some elaboration, has proven of value in private practice as well as in military work.

Even the soldier of considerable experience is liable to certain foot troubles during campaign, and to suffer more or less until he has become accustomed to the new conditions and gotten his "marching legs." I will describe some of the most common marching ailments and recommend methods for alleviating them.

A "*weak foot*" will frequently develop in the early days of strenuous field training and often results in pain and depression of the long arch. This condition might be the result of an accident or of excessive strain. I wish to lay stress upon the fact that we frequently find depression of the long arch of the foot after a severe sprain or fracture of the ankle. Patients who develop "painful arches" and similar conditions on the march should be rested immediately, or at least relieved of arms and pack. Often a very severe pain in the arch can be relieved by proper strapping and bandaging, making it possible for the soldier to march many more miles. I have experimented with cases in which there existed a marked degree of obliteration of the long arch, with eversion of the foot. Supporting the feet of such patients has made it possible for them to carry their arms and pack through a march of 12 to 15 miles. They have also retained their position in column and taken part in the maneuvers of the day. These men, who were intelligent and much interested in the experiment, were certain that they could not have finished the march without the support. The supports were reapplied each day. A ready means of support for a foot which becomes painful on the march is the French marching strap, which is placed under the shank of the shoe, crossed over the instep and then around the ankle and fastened. Often this weakness of the long arch of the foot is aggravated by a faulty construction of the shoe in which the shank is thinner than the sole and the upper sags because of not being fitted well into the arch of the foot.

Another, and perhaps the commonest, disability occurring on the march, especially in new commands, is *blistering of the feet*. Unless a shoe is manufactured with great care irregularities are apt to occur along the edge of the insole. Also the lining of a shoe may shrink and fold. These two defects have been responsible for many blisters. Another cause of blisters is often found in the heel where nails protrude. Overlapping toes are invariably prone to blisters. The best treatment for blisters is to paint them with tincture of iodine 3½ per cent, open with a needle which has been sterilized in a match flame, then apply a small dressing of cotton or gauze held in place with adhesive plaster. If the plaster is applied directly on the blister, without cotton or gauze, the healing is retarded, as adhesive plaster, by its heating effect, is liable to macerate the epidermis; also it may be pulled off too soon, taking the blister with it. Any oily or greasy substance which is non-irritating is a good preventive of blisters. Foot powders containing talc are not nearly as effective as those composed of stearate of magnesia or zinc. The fact that it does not cake and that it is greasy, makes a stearate far superior

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to the ordinary talcum powders, usually recommended. In an emergency soap can be used to reduce friction, but the strong laundry soaps may produce irritation and be worse than nothing. Soiled socks are responsible for many blisters; therefore, they should be washed or rubbed together and sunned frequently.

*Callosities and corns.*—These should be removed by excavation rather than by paring. The latter method simply removes the excess of hardened tissue but does not eradicate the trouble. By keeping adhesive plaster over a callous for several days at a time, the tissue is softened and can then be excavated entirely. The process may have to be repeated several times before a complete cure is produced. Soft corns should be touched with tincture of iodine and protected with a pad of gauze or felt.

*Bunions.*—These are often a cause of poor marching. They should be operated upon, if possible, as mentioned in a former paragraph; otherwise protected with felt, held in place with adhesive plaster. The accompanying hallux valgus should be corrected by holding the great toe in the normal position with adhesive or a molded aluminum splint.

*Tenosynovitis.*—This should be treated by rest and support with adhesive straps and bandages. Often this condition of the tendon achilles is caused by rubbing of the shoe top or lower end of the legging. A shoe with a high, soft upper would prevent most of the irritation usually encountered on this tendon.

*Strained and tired muscles.*—The most effective treatment is by heat and massage and moderate exercise. A certain amount of action in muscles which have not been severely injured is necessary in order to prevent stiffening. If on the march, adhesive strapping or bandaging will generally support a strained muscle sufficiently.

*Ingrowing toe nails.*—These should be operated upon at the earliest opportunity as they are apt to be the source of much annoyance if not treated radically. Small pieces of felt packed under the edges of the nail produce better results than cotton or gauze used in the same manner. The padding should be held in place with adhesive plaster passed well under the edge of the nail.

The soldier can not be too strongly impressed with the idea of the care of his feet, as good care will prevent many of the troubles just described. The feet should be washed at the end of every march, but if this be impossible a good plan is to give them a "dry wash" with some form of grease or oil. Bacon fat can usually be procured; this is rubbed over the feet, particular attention being given to the toes. The grease is then rubbed off with a cloth, or the leg part of the sock. This treatment is cleansing and leaves the skin feeling soft. Clean socks should be put on; or if these are unobtainable the soiled ones should be rubbed together, beaten and put back inside out.

The recruit is apt to place the blame for his foot troubles upon military training, but the majority of ailments to which marching feet are subject are the result of abuse of the foot in civilian life. The country is now suffering from the effects of "good-looking" shoes, and the fact that we are daily refusing the services of men who have been crippled by fashionable footgear proves how important it is to begin a campaign for the education of the public at large, with the idea of arousing sufficient interest and coöperation to make it the "proper thing" to wear footgear which has at least an atom of common sense incorporated in its design. The mothers of the nation should be mobilized as instructors for the grand army of youths who are now making themselves unfit for military service by wearing ill-shaped footgear. Thousands of women are now clamoring to be allowed to perform some service which would be of benefit to the Government. I would like to point out to them the opportunity to enter service at the front, immediately, by refusing to wear shoes that cripple, thus setting an example to our future soldiers. Let them follow the lead of the Chinese women who discontinued the custom of binding their feet a number of years ago. Military training in the public schools would be of great value in impressing upon youths the importance of adhering to sane footgear. Educational institutions should require all students, both boys and girls, to wear a sensible shoe, and proper training of the foot should be included in all school gymnastics. I do not mean that shoe "freaks" should be insisted upon as these are usually the production of some one whose knowledge of the foot and its requirements is very limited. A proper shoe can only be developed by combining knowledge of the foot with understanding of the methods of manufacture. It is hoped that military life will create a greater interest in sensible foot wear, and impress the civilian that he must prepare his feet for service by discarding the type of shoe which is at present fashionable.

*Shoes.*—A shoe devised for hard service, both in the field and in the trenches, must primarily give protection and comfort and should be made of tough leather which should be neither too dry nor too oily, but soft and pliable. The best workmanship must be employed, as skill in manufacture is of great importance. What is known as the Goodyear welt process should be used; this is the most modern mode of manufacture in which no pegs or screws are used, as in some of the cheaper processes. There should be *no lining* in a military shoe, as this is responsible for a great many blisters and abrasions. The leather should be turned with the hair side out. I know that many favor placing the flesh side out, as I did originally, but after further experiments and obtaining the opinion of others who have had experience, I concluded that with the hair side out we obtain better waterproof qualities. The toe should not have more than one inch "spring," as too much tilting upward is conducive to the formation of "claw-toes" and troubles in the anterior arch. The *sole* should be heavy but flexible. These are important points, but are entirely disregarded in the making of most shoes. The combination of *thickness* and *flexibility* is difficult to obtain, but is possible. The *shank* should be neither extremely flexible nor entirely rigid, but should be sufficiently yielding to permit freedom of action of the small bones of the foot. Entirely opposite ideas are being advanced concerning the flexiblity of the shank of a shoe; some would have it so flexible that it can be doubled back with ease, as it is claimed that this freedom is necessary; others would make the shank as rigid as a board. I can not see any scientific reason for either of these, but do favor as much flexibility as possible at the "ball" of the foot, the only part that really bends in walking. It is only necessary to wear a pair of shoes made on this principle to convince one's self that the idea is the correct one. The *toe* of such a shoe should not be soft, neither should it have the ordinary "box." In fact, the box of all shoes is responsible for many foot troubles and should be done away with. Some protection to the toes, however, should be provided in a military shoe, as otherwise they are exposed to injury from stones and stubble. The best form of protection can be given by a narrow *protector* of stiff material placed at the extreme tip of the shoe. The *upper* of the shoe should be at least six inches high, thus giving much more comfort than the ordinary civilian shoe top, which reaches just above the ankle joint. There should be no "back-stay" or loop for pulling on the shoe, these are unnecessary and often cause trouble by friction. The *tongue* should be soft and "full bellows." The heel should be no more than one inch in height. *Hob nails* are essential for a real marching shoe, but they must be placed so as not to interfere with the flexibility of the sole. A shoe which requires much "breaking in," or soaking in water, to make it conform to the foot, is not fit for military use. The *repair* of *military shoes* should be performed by a first-class workman. Every company of infantry should have an official shoe repairer whose tools and leather ought to be supplied by the Government. The leather for repair of soldiers' shoes should be carefully selected as the quality of that used by the ordinary shoemaker is not good.

*Socks.*—It is not usually supposed that socks have much to do with foot deformities, but it is true that the ordinary civilian sock exerts sufficient pressure upon the toes to cause them to overlap. It is quite evident that if the toes are constricted by socks they do not have the necesary feedom of motion and the good effects of a broad toe shoe are counteracted. Socks should be either rights and lefts or so woven that there is ample fulness at the toes. A military sock should be made of wool, or part wool, of sufficient thickness to protect the foot.

In conclusion I wish to urge upon all physicians the necessity for greater interest in this important problem and in creating a demand for sensible footwear. I find that it is the usual thing for general practitioners to advise patients suffering with painful or abnormal feet to purchase some much advertised shoe, without any definite idea whether or not it is applicable to the case; this is at least risky therapeutics. Weak foot and its accompanying evils are conditions which should not be dismissed by recommending them to the tender mercies of a shoe salesman. It is of the utmost importance that a proper diagnosis be arrived at and that these cases be treated scientifically.

## The Breadfruit

**By C. D. Mell**

This important fruit that was at one time believed to take the place of wheat bread in the tropics, is produced by the tree botanically known as *Artocarpus incisa*, a plant indigenous to the Island of Otaheite in the South Sea. The early traveler in the South Pacific returned home with very glowing descriptions of the value of this fruit. One of the English botanists called it "the most useful vegetable in the world" and urged the English Government to spare no expense in the cultivation and distribution of the tree in its tropical possessions. The enthusiastic accounts given by a number of travelers soon attracted the attention of the English colonists in the West Indies, where the climate is sufficiently warm to grow the tree successfully. The tree was first reported upon in about 1688 by Captain Dampier, but it was not until a hundred years later that actual steps were taken to cultivate the tree in the British West Indies.

In 1787 a number of influential planters in the colonies requested George III to fit out an expedition to distribute young plants throughout the West Indies. The request was granted and a vessel of about two hundred and fifty tons' capacity was commissioned to go to Otaheite and bring a number of young plants to the West Indies. An account of this voyage contains the information that over a thousand young live plants were secured and carefully potted for distribution at various ports in the West Indies. Unfortunately, however, a mutiny occurred on board and the boat never reached its destination. A few years later another expedition was sent out and in 1793 the captain succeeded in distributing young plants among colonists on St. Helena, St. Vincent and Jamaica. It soon attracted the notice of the public generally and it did not take many years until the breadfruit tree was growing successfully throughout entire tropical America. Yet after all the expensive preliminary work in collecting and distributing the young plants and the careful and painstaking cultivation that followed until the plants were thoroughly naturalized, the tree never met the expectations that were entertained by the promoters.

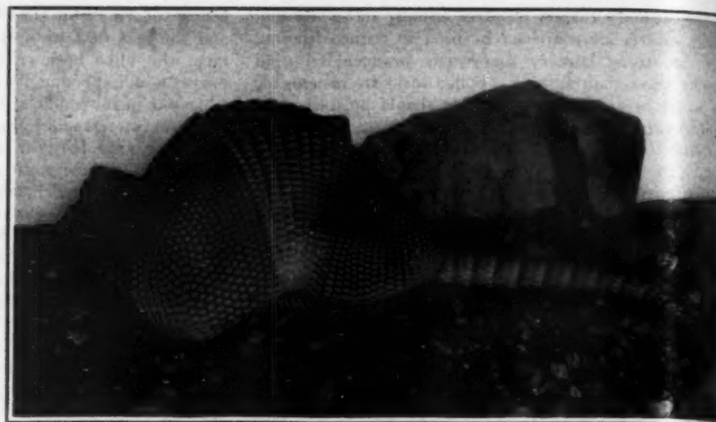
The tree may be described as one of the most beautiful and unique plants in tropical America. It attracts the attention of all travelers. It grows to be about as large as an ordinary apple tree with a broad head full of branches and numerous dark-green leaves that are deeply incised, a character from which the tree derived its specific name. The fruit (so called) is very interesting and grows on branches like apples. It is composed of a great many fruits similar to the mulberry, forming one mass or unit that varies from six to twelve inches in length and from three to six inches in diameter, although many of them are nearly round. They have a thick, tough rind, which, when ripe, turns yellow and soft. On the surface it is marked with a peculiar pattern indicating the place of the female flowers. The true fruit consists of a portion of the whole with a nut embedded in it, but the nuts are seldom present in the cultivated varieties. The interior is soft and spongy, almost similar in consistency to that of newly baked white bread. It has a sweet and pleasant taste and in some of the islands of the South Sea it is used for bread exclusively.

The bread fruit is always gathered in the green state and while it is still hard. A favorite method is to bake it in an oven until the rind is thoroughly scorched and turns black. This outer black portion is scraped off and the inner and more tender part is eaten. The cultivated variety has no seed at all in the inside, but when properly treated is one mass of tender substance almost similar to that of bread. The fruit is perishable and rarely lasts for more than twenty-four hours after it is removed from the tree. The trees that have in part reverted to the wild state bear fruit with seeds in them, and in many parts of the West Indies these seeds have become valuable as a food. They are called castana or bread nut and bear some resemblance to our common chestnuts. They constitute an article of food, being prepared by first boiling them in water for a few moments before eating. These seeds resemble the bread nuts from the "Jack tree" (*Artocarpus integrifolia*), a tree from the East Indies that is now very common throughout the entire tropics. The seeds of both varieties of *Artocarpus* constitute an important article of native food; thus far the nuts have not been exported to any extent.

The tree has other uses in a small way besides being an ornamental tree, very commonly planted in parks and around dwellings. A substitute somewhat resembling rubber may be made by boiling the milky mucilaginous juice of the bread fruit tree with cocoanut oil.[1] The resulting material is said to be tough, durable, and waterproof, and is called "canoe gum," because it is used to close the seams of canoes and wooden utensils. Before hardening it also serves as bird lime. The wood, though little used, is said to be highly appreciated for furniture and for building houses.

[1]Economic Plants of Porto Rico: Cook and Collins.

Nine-banded Armadillo (*Dasypus novemcinctus*); much reduced. From life by the author



The Armadillo starting to roll itself into a ball. Same specimen as shown at left. From life by the author

# Anomalies in the Animal World—Part III.

## Animals That Wear Armor, With Remarks on the Different Species and Their Habits

By Dr. R. W. Shufeldt

In so far as the power to inflict any external physical injury upon the body or form is concerned, no vertebrate in existence on our planet today is more vulnerable in this respect than man. Except such protection as the hair of the head may occasionally render, he possesses nothing beyond a thin and delicate skin, standing between his internal organs and structures, to protect the latter from external injury of any kind whatever. As a means of defence against such wounds, however, the great freedom in the use of his limbs affords man protection, in many instances, of a most efficient character. This only happens when they come voluntarily—or sometimes involuntarily—into play for such a purpose; beyond this, man has manufactured his own armor. It is seen in the coverings, of many kinds, of his naked body, all the way from the most delicate and thinnest of tunics to the metal armors of the Middle Ages. Many peoples wear—at the present time, in various parts of the world and on certain occasions—devices akin to those armors, to serve the same purpose—that is, of corporeal protection.

Many animals in the world of invertebrates are absolutely at the mercy of almost any agent that aims to wound or destroy them; this is the case with millions of insects and their kind, with marine forms, with worms of nearly all classes, and with thousands of other creatures. Mere mention is made of these in order to invite the reader's attention to them, as other means of bodily protection are referred to in the course of what follows.

During the millions of years that have passed over the world since life first appeared in it, unnumbered hosts of animals of every description—both armored and unarmored—have come into being, flourished, and, in the majority of cases, eventually become extinct. Whether armored animals—everything else being equal—lasted any longer, were any safer or happier, is a question, the answer to which can but be of a speculative character.

It would seem, however, in so far as the evidence goes, that such animals did enjoy a far greater longevity than others not so protected. Some immense land tortoises, now extinct, came to be fully one thousand years old as the measure of their individual life-span. Probably such creatures as the glyptoden attained to some such marvelous age, as well as some of the pondering giants in the world of Reptiles of those long-ago periods; many of these have been preserved as fossils, and these latter are in the hands of science.

Millions of the unarmored forms were so constituted that, when they perished, they were of so delicate an organization, so utterly lacking in any hard structures, that any species of fossilization was not possible for them; they passed away forever, leaving no more trace of their existence than a sea-nettle would leave, were it to die today and come to land on a soil where, were it a turtle or some other armored animal, it would fossilize—that is, its denser and less perishable parts would.

Trilobites fossilized, but not jelly-fish; trilobites occurred in the Silurian, untold ages *before* the carboniferous; and Le Conte tells us that the latter strata required one and a half millions of years to accumulate. Comparatively few there are who have given this a thought, much less pondered upon what it means.

Ever since life was well established on the globe, then—that is, at a time when forms of all kinds had gained some considerable degree of *complexity*, there have existed variously armored special of both vertebrates and invertebrates during the ages when they flourished. Armor of all manner of descriptions evolved in the case of animals of all orders, as other structures have evolved under the operation of the laws of organic evolution. Doubtless its prime object was bodily defence and protection; but in nearly all instances, to this was added secondary sexual characters, involving beauty, adornment, sexual attraction, and sometimes special utility in addition to bodily protection. As a single example of the last, it is sufficient to cite the richly colored scutes that overlie the osseous armor of so many land tortoises, or the brilliant black and orange armor of a Heloderma, that very much over-dreaded lizard of our southwestern districts.

At the present time animals that possess armor of one sort of another are found all over the world. Only a few of the vertebrates can be considered in this chapter, for an entire volume might easily be devoted to such a subject.

The possession of a complete armor is very common among fishes; as a matter of fact, the scales of fish, when of sufficient size and thickness and covering the greater part of the body, form a most effective protection against its injury. On the other hand, however, some fish, as the well-known "trunk fish," are completely encased in a dense, bony armor covering the entire body. The eyes, all the fins, the lips, and other small, necessary apertures alone are movable, these appearing in openings at the sites where they occur, held in position by surrounding tough skin.

Among other places, trunk-fish of several species occur on our South Atlantic coasts and in the waters of the tropics south of them. Captive specimens may always be studied at the New York Aquarium where three or four species may often be seen at a time.

The armor of a trunk-fish completely protects the entire internal anatomy of the animal; and so heavy and thick is it that, in a large specimen or one over a foot long, it requires a pretty heavy blow with a hammer to crack it. This fish has been dissected by me numerous times, and skeletons made of the entire bony framework of the specimens so treated. The armor is made up of numerous platelets, hexagonal or otherwise, held together by a tough fibrous tissue. A most beautiful structure, completely adapted to the fish's protection.

Another strangely armored fish is seen in our Porcupine-fish, in which the *linked*, bony armor is not only a complete corporeal encasement, but each of the curiously shaped individual links composing it bears a sharp, bony spine. In a big specimen, these latter range in length from a mere nib to a spike, as sharp as a needle, an inch or an inch and a half long. This entire porcupine array can be elevated and lowered as the fish desires, the whole not only forming a most complete armor, but a bristling array of needle-pointed spines of great strength that no ordinary animal living would care to come into contact with.

Our beautiful little Burr-fish is another armored species, which is abundant in tropical and subtropical waters or even as far north as Cape Cod, in the case of one species.

In the "swell-fishes" and "file-fishes"—relatives of the forms just noticed—the armor is reduced to a thick, very tough, dermal coat-of-mail that thoroughly protects these species from bodily injury of many kinds.

Armored fish of one kind or another occur in many other parts of the world, but those just mentioned stand among the most striking examples to be found on our own coasts, though the peculiar armor of sturgeon and "sea-horses" must not be overlooked.

Coming to reptiles, we meet with quite a numerous array of species, belonging to widely separated families and genera, that possess some kind of an osseous coat-of-mail. Many lizards have a tough, leathery hide, the scutes of which sometimes ossify or even support bony spines. Examples of the former are seen in chameleons and in the rare and extraordinary "tuatera" of certain islands off the coast of New Zealand, while the "spine-tailed" lizards of Western Australia form excellent examples of the latter.

Mr. W. Saville-Kent, who has frequently photographed the tuatera on the islands where it occurs, says that externally it does not differ materially from an ordinary lizard; the "skin however, is peculiar for its leathery, granulated, and wrinkled texture; there is no trace of external ears; the eyes adapted for nocturnal vision, have in daylight vertical pupils; and the bases of the toes are united by connecting webs."

Its internal anatomy is remarkable; but what most interests us here is the fact that its abdominal ribs are so modified that they "find their near equivalent in the breastplate of tortoises and turtles."

This famous lizard occupies an order all to itself, and has been very scarce of recent years. The government, however, is now protecting it, as it is extremely interesting to science and a great destroyer of noxious insects in the green-houses.

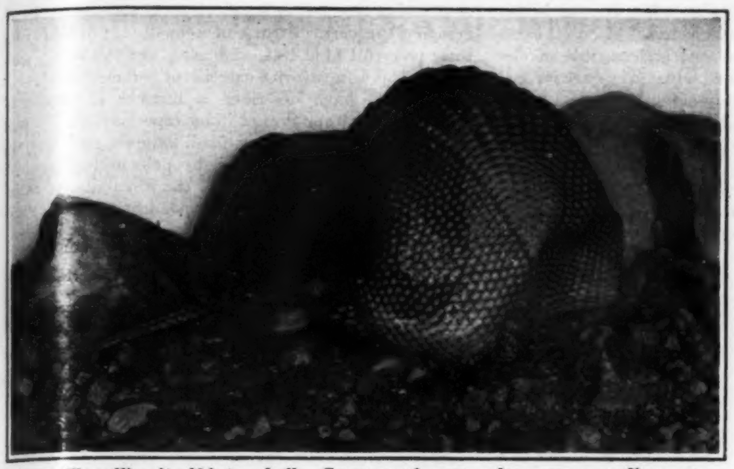
Mr. Saville-Kent goes on to relate that "Among the multitudinous gift of which their Royal Highnesses the Prince and Princess of Wales were recipients during their recently accomplished world-embracing tour, a pair of living tuatera lizards formed one of the most singular and highly prized contributions accepted from the loyal New Zealanders."

Our Heloderma ("Gila Monster"), has already been mentioned above as possessing an armor of very considerable effectiveness; but this is not nearly as much so as is the spiny armature of the remarkable "girdled" lizard of South Africa.

Then we have our well-known horned lizards ("horned toads"), various species of which occur in different regions of the West and Southwest. They not only possess a tough, leathery skin, supporting its semi-osseous spines, but the head of the most conspicuous species appears as though it were helmeted, with long, curved spikes behind.

Strangely enough, another spiny lizard (Moloch or Mountain-Devil), occurs in Central Australia, which, in some respects, reminds one of our western "horned toad," and probably has habits not altogether unlike it.

The Moloch rarely exceeds six or seven inches in length, while "its feeble form and stature, however," says Saville-Kent, "are abundantly compensated for by the complex panopy of spines and prickles by which its head and limbs and body are effectually protected. The natural food of this singular lizard consists exclusively of ants, the small, black, evil-smelling species which often proves itself a pest by its invasion of the Australian colonists' houses being its prime favorite. These are picked up one by one by the rapid, flash-like protrusion and retraction of the little creature's adhesive tongue, and the number of ants which are thus assimilated by a



Armadillo rolling itself into a ball. Same specimen as shown on preceding page. From life by the author

Armadillo asleep. Same specimen as shown in preceding views. From life by the author

Moloch lizard at a single meal is somewhat astonishing. A number of examples of this species were kept by the writer in Australia, and their gastronomic requirements fully satisfied every day by taking them into the garden and placing them in communication with a swarming ant-track. By careful observation it was found that no less than from 1,000 to 1,500 ants were devoured by each lizard at a single sitting. The ant-devouring proclivities of these prickly little lizards can no doubt be turned to very useful and effective account in clearing ant-infested domiciles, and were in fact thus utilized by the writer on more than one occasion."

Passing to another group, we are all more or less familiar with the leathery armor of alligators, many of which are still to be found in certain parts of the Gulf States. Here the armor consists of the thick, tough dermal covering in which there are imbedded, principally in rows down the back and elsewhere, dense, bony plates of various sizes according to locality. Many an alligator's life has been saved through the efficiency of the protection afforded by its armor, as many a one will be in the future.

Snakes are frequently protected in a way by their tough, scaly skins; but for very obvious reasons, the agile creatures rarely possess anything beyond this; while most frogs, toads and their allies among the Amphibia are, as a rule, not only not armored but extremely vulnerable with respect to bodily injury. Some frogs and "tree-toads," for example, possess thin and most delicate skins that any sharp-pointed little thing will easily puncture.

Of all animals, none present a more complete armature than do most of the *Chelonia*, that is, the turtles and tortoises. Our common box tortoises, for example, are not only encased in a complete osseous *box*, but they have a hinged plastron that admits of shutting to the anterior and posterior parts of it in such a manner as to close out from view the occupant of the "shell" entirely. It is, when thus closed, actually water-tight, and, by the muscular action of the owner, it is not a feat to be easily performed to open the "box" even when an instrument of some kind or other is used for the purpose.

Several species of our American land tortoises possess this arrangement (*Cistudo Kinosternum*, etc.,) and it protects them completely against all ordinary attacks and injuries. Our beautiful little box tortoise, however, is often the victim of thoughtless and cruel boys who come across them in the woods, and being piqued at not being able to open the "shell," often kill the poor creature with a stone. An entire chapter could be written on the life histories and descriptions of the remarkable elephant tortoises of the Galapagos Islands, and on several other species which are still to be found in Madagascar, the Seychelles, and the island of Aldabra. They are being rapidly exterminated, and to save a few of them the London Zoölogical Gardens have furnished suitable enclosures for a large number which now occupy them in comfort.

An elephant tortoise may weigh 400 pounds, attain a length of four feet, and be 400 years or more old. Every one interested in these giant tortoises should read Darwin's elegant account of them in his "Voyage of the Beagle." They were very abundant on the Galapagos when he visited those islands; while in 1691, in the island of Rodrigues, they were in such numbers that a flock of 3,000 was not an uncommon sight. In passing from place to place in their regular habitats they are slow travelers, for they can only make a yard per minute or about four miles per day.

Some of the "soft-shelled" fresh water turtles possess shells wherein the carapace and plastron are, to a certain degree, open and slender through the peculiar formation of the bones composing them. Such species enjoy but slight protection from the armor they possess, while on the other hand, their plain colors protect them, and they are swimmers of prodigious power.

Coming to the very homogeneous group of birds, the only armature any of them may boast of is their plumage, which is not altogether to be despised. Such protection as the feathers afford is, in the vast majority of species, confined to the adults. However, if we take a full-feathered, old turkey or a swan as examples, we may by experiment learn that their bodies are very largely protected by their anomalous coat-of-mail, notwithstanding the fact that it is only composed of feathers. Many a bird has escaped bodily injury most completely owing to the presence of its feathers. In this they are assisted by the peculiar freedom enjoyed on the part of their pectoral limbs or wings. Birds often shield themselves successfully against injuries or attacks by the skilful use of their wings. Added to all this, they have the protection in the means of escape, at their command, of flight, or, in many species, of aquatic habits of diving beneath the surface of the water. Certain parts of their plumage comes into play in both of these faculties.

Finally we have the mammals, a group represented in all parts of the world, and one that not only offers numerous interesting anomalies but quite a number which have their bodies protected by armor of the most efficient kind.

In all ordinary mammals the pelage is more or less protective, and the thicker, finer, and more woolly this is, the greater amount of protection it affords. As a rule, the majority of the higher simians, monkeys and apes, are better protected by their pelage than any of the representatives of the genus homo, or better, mankind as a whole. As in the case of man, they are further protected by the facility with which they can use their limbs, and instantly bring them into play in the matter of defence of the body. Moreover, their marvelous agility counts for a great deal, and both men and monkeys often escape injury through the exercise of these faculties.

Among the majority of the carnivora and rodentia we meet with no forms furnishing examples to illustrate the main subject of the present chapter. The extent of the protection varies with respect to the nature of the pelage; the agility of the animal, either on land or on water, coupled with some other advantages, as its intelligence and so on.

Some mammals have special parts protected in certain ways, as the beaver has its tail for example.

A more general body protection is afforded in the case of the quill-armor of some of the porcupines, especially the one found in some parts of southern Europe and northern Africa. It hardly applies to the small-quilled porcupines of our country and other animals having similar characters.

Bats of all kinds have additional protection in their being perfect fliers, and at the same time very quick in all their movements. Unless actually captured, it must be quite a rare incident for an adult, healthy bat to receive any bodily injury. Many of them are killed by man, to be sure, and very likely more are injured or destroyed by him than in any other manner.

Although the larger existing pachyderms, as the elephant, tapirs, rhinoceroses, and the hippopotamus of another group, possess no armature in which bones enter as an element, they all have a very complete armature in their tremendously thick and tough hides. This applies especially to the rhinos, for their dermal encasement is so thick and largely impregnable that it affords even better protection to its owner than some of the species of armor do. However, there are probably no hides of existing mammals tough, thick, or bony enough to afford any protection against the bullet from any of the modern high-power rifles at ordinary range. At close range they may pierce the animal through and through, either from side to side, or end to end, as the case may be.

The dense osseous plates—or rather united plates, between the skin and the skull (behind the orbits) in the curious African mammal *Lophiomys* offers an example of a peculiar armor for the back of the skull, over the brain-case, which, for space limitations, it is impracticable to discuss here. It would quickly lead to the taking up of some biological questions for which science has, as yet, found no satisfactory answer or solution.

Manifold as are the devices for bodily defence which have evolved and become more or less perfected among the Mammalia, there is no group in which this has been more effectively encompassed than among the armadillos and the pangolins—particularly the former.

In my life-time, thus far, I have availed myself of a few excellent opportunities to study the armadillo in captivity—one or two species of them; also to dissect the nine-banded one which, in the United States, is found in certain parts of southern Texas.

The arrangement of the armor over the head and limbs of this remarkable animal; over its feet and dorsal aspect of its trunk, and the elegant rings of the long tail are so clearly seen in my figures illustrating the present chapter that no detailed description seems necessary. They are gentle, inoffensive creatures, having various accomplishments which they readily display in nature as well as in captivity. It is said that they are good swimmers; that they can run with great rapidity; burrow at a most incredible rate, and, with respect to some species, roll themselves up into a ball as round as you please, in which case all their vulnerable parts are thoroughly shielded by their beautiful coat-of-mail, with limbs and tail entirely hidden from view. If you are riding alone on horseback in the country where the burrowing armadillos occur, and you meet with one where the soil is somewhat light or soft, and you desire to capture it alive, you must be quicker than a flash if you expect to succeed in your object; for the fellow will start to burrow the instant he perceives you. And however alert you may be in dismounting and getting over the ground, he will be well down into the ground before you can reach him. Then it is like pulling up a young tree with one hand to dislodge him by tugging at his tail; he will allow you to almost pull it off before he will let go his hold.

In the western part of the Argentine Republic, we meet with a curious little species of armadillo known as the Pichiciago, which has a length of less than five inches. It has a snow-white pelage with the horny covering to its osseous armor a beautiful pink color. What is most extraordinary in this species is the manner in which its armor is attached. It is composed of unusually small plates, coated with the horny outside layer as in all other armadillos. This shield is *arched* over the body, being attached only down the middle of the back, thus creating a space *between* the armor and its very hairy little white body. The armor posteriorly is a *vertical* semicircular plate of some size, giving that animal a still more remarkable appearance.

There are a good many species of armadillos, and they feed on everything from insects to the rankest of carrion. One called the peludo catches mice by jumping on them, and, encircling his victims in the concavity of his armature, they are promptly dispatched and devoured.

Mr. Lydekker says that this peludo also preys upon snakes; "it has been observed," he says, "to kill a snake by rushing upon it and proceeding to saw the unfortunate reptile to pieces by pressing upon it closely with the jagged edges of its armor, and at the same time moving its body backwards and forwards. The struggles of the

snake were all in vain, as its fangs could make no impression upon the panoply of its assailant, and eventually the reptile slowly dropped and died, to be soon afterward devoured by the armadillo, which commenced the meal by seizing the snake's tail in its mouth, and gradually eating forward."

In many armadillos the hair grows in between the plates of the armor, and in some forms this is quite abundant; there is always more or less hair growing all over the under parts.

There is still another armored mammal deserving of our notice before bringing this chapter to a close; reference is made to the pangolines or scaly ant-eaters (*Manis*). These inhabit South Africa and southeast Asia. They are toothless, with long, vermiform tongues, which they employ like the ordinary ant-eaters in capturing their prey: ants and some other insects.

A pangolin or manis looks like a big fir-cone in his remarkable armor, for the latter consists of great, overlapping scales, each being pointed and capable of elevation to a right angle with the body. They are formed by an agglutination of the body-hairs, but are as tough as bone. This creature can also roll itself up into a most perfect ball, as round as an orange. This it will sometimes do high up in a tree, and voluntarily drop to the ground below, in order to save itself the trouble of climbing all the way down through the tree.

In passing, we may name the hedgehog, which is another spiny little animal of Europe, that also can roll itself up into a round ball, when it becomes about as comfortable to handle as a dry, old chestnut-burr.

Pangolins use their tails with great dexterity in tree-climbing, the under side of which long appendage also supports a series of pointed scales. They have a way of swinging themselves in a horizontal position by firmly grasping the vertical trunk of a small tree or limb with their powerful hind legs, and using the tail as the support. This is a favorite exercise of the manis.

Zoölogists have described a number of species of pangolins, but they do not differ especially with respect to their habits. Numerous fossil animals, now long ago extinct ,have been described by paleontologists which were armor-covered relatives of the armadillos of extraordinary kinds, and often of ponderous size. These cannot be touched upon here, nor do they legitimately fall within the scope of the present work.

Civilized man no longer dons an armor, as the necessity for such has ceased to exist. All that passed forever in our species when given up by the elegantly armored knights of the Middle Ages.

[TO BE CONTINUED]

## Color Method For Analyzing Wood Paper Pulp

A FRENCH chemist, M. Pontio, brings out a new method for estimating the amount of wood fiber contained in paper pulp, which is based upon the formation of color with certain reagents, and is thus analogous to the well-known color method used in analysis of carbon in steel. Paper pulp comprises three general classes, namely, pure rag pulp, wood pulp on the bisulphite process, known as chemical pulp, and wood pulp on the mechanical process. Mixed with these, there are also employed various straw or esparto pulp, and others. It is desired in the industry to have a quantitative estimate of the different catagories of cellulose contained in the paper, but such methods are lacking at present. The only way to make such an estimate is by a calculation based upon the number of fibers of each class which are observed in a given microscopic field, but this method is far from being exact, and can hardly be said to have a commercial value. Several methods have been suggested for estimating the amount of mechanical wood cellulose contained in a given paper pulp, among others Dr. Wurster's method which makes use of the color shown by a reagent containing dimethyl-paraphenylene-diamine, and Muller's method based on the fact that cellulose is dissolved by ammoniacal copper oxide, but these methods do not appear to have a practical application and are but little employed. The author sought for a color reaction method, based on the numerous color reactions shown by wood fibers, one of these being the reaction of iodine and sulfuric acid upon vegetable cells. The different classes of cellulose in paper pulp are treated first by iodine and then by sulfuric acid (after having removed the excess of iodine), and it is observed under the microscope that pulp made from rags now takes a violet-brown color, mechanical process wood pulp becomes yellow and chemical wood pulp as well as straw and esparto cellulose assume a blue color. But if subsequently the pulp is diluted with a sufficient amount of water, the pure cellulose (rag, chemical wood, straw and alfa) discharges its color and now appears as colorless while the mechanical wood pulp remains with a yellow hue. Starting from this fact, the author considered that in the case of a mixture of different kinds of cellulose in suspension in a suitable liquid, the coloration will be yellower in proportion as the mixture contains a larger amount of mechanical wood cellulose. In order to verify this, he made two standard liquids, one containing only mechanical cellulose and the other only chemical cellulose in bleached condition. The solutions are prepared as follows: Treat 1 gram. of each pulp with 100 c.c. soda lye (2 per cent) solution, by boiling for five minutes. Filter upon wire gauze and wash until a neutral reaction is obtained, then dry at 100 deg. C. Take 0.02 gram. of the dry pulp and saturate it with iodine by the use of a solution containing 3 gram. iodide of potassium per 100 c.c. distilled water and also iodine in saturation. Remove the excess of iodine from the pulp so that it will show no trace of color when pressed between filter-paper. Of this prepared substance, place 20 mg. in a standard bore glass test tube (all such tubes to have the same inside diameter, say 15 to 18 millimeters), and add 20 drops of a solution composed of 66 degree sulfuric acid 22 c.c.; water 16 c.c.; glycerin 16 c.c. Rub up the whole in the tube by using a glass rod, and when smooth and even, add 10 c.c. of a solution of equal parts of (30 degrees) glycerin and water. Stopping with the thumb, shake up the tube well, and then observe the color of the mixture. This color corresponds to a given standard percentage of cellulose in the solution, and it only remains to establish a series of colors by using different tubes each containing another standard percentage of the wood cellulose, so that the scale comprises a set of tubes representing percentages along a range such as is required in actual practice. These standard colors are now fixed once for all upon a sheet of paper by the use of water colors, or they can even be lithographed. This color scale is then employed as a standard in all cases for use with samples of paper in which it is desired to determine the percentage composition in mechanical process wood cellulose. The author finds that unbleached pulp does not exert any marked influence upon the color produced. Only such vegetable fibers as become colored in yellow by iodine, such as jute, for instance, could cause any appreciable error. Although this case is rare, it can very well be provided for, and the above analysis can always be accompanied by a microscope examination in order to make any needed corrections for such cases.

## Games of the Labrador Eskimo

THE game of cup and ball (*ayayau'k*) is played in Labrador as among the Central Eskimo. A rabbit's skull or a cone-shaped piece of ivory is bored full of holes, and a peg of ivory, about 4 inches long, is attached to it by a thong. The game is to pierce the holes with the peg when the skull or ivory piece is swung on the end of the thong. In an old specimen in the Museum, the ivory piece is in the shape of a bear. There is a definite order to the distribution of the holes in the ivory and the way in which they must be pierced. There is a triple line of holes on the abdomen and sides of the bear, but only a single line on the back and throat, and a single hole at the head and tail. During the first ten throws, the player may pierce any hole in the abdomen or sides. Beginning at the hole in front (in the head) he next must pierce the line from the head to the tail. If he misses more than once, he has to give place to another player. After successfully taking the holes in order, he may continue piercing any hole until he misses one.

A game (*tingmiay'ax*) similar to dice is played with ivory images of birds. There are fifteen to eighteen figures used in the game. Small images of men and women are also used. The players sit around a dressed sealskin. The images are taken in the hand, shaken, and thrown up. In falling, those that stand upright belong to the player. The one who succeeds in getting the greatest number is declared the winner.

The Labrador Eskimo also play a game with small ivory pieces covered with dots in varying patterns which appears to be an adaptation of dominoes (*amazua'lat*). This description of the game is taken from Turner:[1]

"Two or more persons, according to the number of pieces in the set, sit down and pile the pieces before them. One of the players mixes the pieces together in plain view of the others. When this is done he calls to them to take the pieces. Each person endeavors to obtain a half or third of the number if there are two or three players. The one who mixed up the pieces lays down a piece and calls his opponent to match it with a piece having a similar design. If this cannot be done by any of the players, the first has to match it and the game continues until one of the persons has exhausted the pieces taken by him. The pieces are designed in pairs, having names such as Kamiu'tik (sled), Kaiak (canoe), Kale'sak (navel), A'mazut (many), Atau'sik (one), Ma'kok (two), Pingasut (three), Sita'mût (four), and Ta'limut (five). Each of the names above must be matched with a piece of similar kind, although the other end of the piece may be of a different design. A Kamiutik may be matched with an Amazut if the latter has not a line or bar cut across it; if it has the bar it must be matched with an Amazut."

I found on inquiry that the game of cat's cradle was known among the Labrador Eskimo, and played by the adults during the dark days of winter for amusement. I was unable to get any specimens in summer, but informants told me that the Labrador Eskimo made the characteristic forms—the deer, the dog, the sledge, etc., which are found among the western and central Eskimo. The game is a favorite with the women and used to amuse the children.

[1]Ethnology of the Ungava district, pp. 257, 258.

Specimens of dolls, the chief playthings of the Eskimo girls, were obtained from Labrador, Baffin Island, and Chesterfield Inlet. They have an extra ethnological value in reflecting in miniature the dress of the district from which they come. Little Eskimo girls "keep house" with them in little snow iglus in winter or in old tent circles in summer, much as their civilized sisters would do. I saw in an old summer camp in Hudson Bay such a playhouse with its little fire-place and lamp of brightly-colored pebbles and bed of moss, mute witness to the active little minds and hands of bygone Eskimo children.—*Geological Survey, Canada, Arthropological Series No. 14, By E. W. Hawkes.*

## On the Relativity of Rotation in Einstein's Theory

OBSERVATIONS indicate that the relative accelerations of material bodies at the earth's surface differ from those which would be caused by Newton's law of gravitation only. The difference is explained by Newton's law of inertia, combined with the rotation of the earth relatively to an "absolute space." Newton quite deliberately introduces absolute space and time as an element of his explanation of observed phenomena. Objections against the above are based on the logical claim that a true causal explanation shall involve only observable quantities. It has been tried to replace the absolute space by the fixed stars by the "Body Alpha," etc., but all these substitutes are on a par with the absolute space itself. Einstein also rejects the absolute space, but he apparently still clings to the "ferne Massen." The author opines that Einstein has made a mistake here. The general theory of relativity is in fact entirely relative and has no room for anything whatever that would be independent of the system of reference. The need for the introduction of the distinct masses arises from the wish to have the gravitational field zero at infinity in any system of reference. This wish, however, well founded in a theory based on absolute space, is contrary to the spirit of the principle of relativity, and the author demonstrates this by a consideration of the fundamental tensor $g_{ij}$. Rotation is shown to be relative in Einstein's theory, but not physically equivalent to translation, the fundamental difference being that the latter is an orthogonal transformation (Lorentz-transformation) of the four coördinates, or world-parameters, and the former is not. New orthogonal transformations are the only ones that leave the line-element invariant in the coördinates, *i.e.*, that do not affect the $g_{ij}$, and are therefore without influence on the gravitational field. Consequently linear velocity may be transformed away by a Lorentz-transformation, but not so rotation any more than mass, and this is a fact independent of all theories. For Einstein, who makes no difference between inertia and gravitation, and knows no absolute space, the accelerations which the classical mechanics ascribed to centrifugal forces are of exactly the same nature and require no more and no less explanation than those which in classical mechanics are due to gravitational attraction.—From a note in *Science Abstracts* on an article by W. DE SITTER in *K. Akad. Amsterdam.*

## Anthropological Research in Canada

THE Geological Survey of Canada has been conducting a number of interesting operations during the past season. In Nova Scotia, Harlan I. Smith has been conducting investigations of the shell heaps of Merigomish and important results are anticipated, as it is known that the country around the Gulf of St. Lawrence was formerly inhabited by no less than four totally different peoples. In southwestern Manitoba W. B. Nickerson is continuing the explorations of the mounds, earthworks and village sites; and W. J. Wintemberg is examining a section of the country between Prescott and Peterborough for a site of culture different from that of the Roebuck site where he excavated in 1912.

# The Development of Commercial Dirigibles*

## A Problem Now being Seriously Considered in England and Germany

By R. B. Price

To anyone who has the opportunity to see what England is doing in the aeronautical field, it becomes clear that she intends to dominate the air just as she today dominates the sea. She is literally building aeroplanes by the thousand and dirigibles by the hundred. Her interest in dirigibles is not confinded to any one type, but she is pursuing the problem with open mind and evidently intends to learn all that can be learned relating to the lighter-than-air mechanism. Nowhere in France could I discover any great interest in the future of the dirigibles and even those actually engaged in the industry saw for it only a moderate usefulness as a naval auxiliary with no promise whatever for commercial service. While England's vision of the usefulness of the dirigible is undoubtedly largely inspired by the vital importance of her naval protection and the established value of dirigibles for submarine hunting and coast and naval scouting in general, yet it seems likely that the impetus given to the development of the dirigible for these reasons will expand into a determined effort to make such craft so useful for commercial purposes as to help sustain the burden of supporting a considerable military dirigible establishment. One of our leading naval authorities has recently stated that if we in America possessed complete designs for a Zeppelin and with every detail of information regarding its construction and assembling, it would still take two years before we could produce a serviceable Zeppelin. Nor must we overlook the fact that it took Count Zeppelin ten years to find out most of the unsuspected dangers arising from imperfections in design and construction and operating dangers that thorough scientific foresight could not provide against nor even in some cases foresee. To the uninitiated it must have come as a great surprise to read of the difficulties and complications which Santos Dumont experienced in developing his early dirigibles. For what reason we do not know, it is only since the war started that Zeppelins have been so shaped as to take advantage of the more recent knowledge relating to streamline shape, decreased resistance, and similar factors. Presumably the need for maximum speed even at some sacrifice of lifting power has been emphasized by military developments. Probably the Zeppelin today stands forth as the world's foremost product involving the most recent scientific knowledge possessed by mankind. Within the past four months a British engineer officer about to attend a test of one of the lastest British rigid dirigibles expressed the fear that she would break her back. It is thus evident that the development of such machines is yet absolutely in its infancy and we have no more right today to conclude that such craft will not in the course of a few years be of extreme commercial value than we have to say that no further progress will be made in engineering, chemistry, physics and education.

It is impossible, in a short paper, to enumerate the scientific problems involved in the construction of even a small dirigible, but it is safe to say that the most complete and up-to-date knowledge of the various sciences involved will be none too effective in meeting the problems of construction and operation, not only for military purposes, but perhaps to an even greater degree for successful commercial operation.

The commercial problem, however, has several elements to distinguish it from the military problem. Until there are aerodromes, repair shops and persons skilled in the handling and repair of dirigibles near almost every community where dirigibles are likely to be used, it is not to be expected that any considerable number of dirigibles could be in service. In spite of the great increase of meteorological knowledge, there will always perhaps be danger of such craft being swept from their courses by unexpected storms, and adequate places of refuge with trained assistants, day and night, must be provided before a general use of dirigibles can be successful. This involves, in addition, aerial charting of courses, development of comprehensive day and night signal systems and the necessary skill in using them. To a considerable extent, the aeroplane problem has corresponding needs and undoubtedly the development of the aeroplane will be sufficiently rapid to force provision of some such facilities for air navigation in the near future.

The expense of operation and maintenance is of minor importance for military purposes, but of paramount consideration for commerce. The bags of most of the balloons that have been used in the past have been constructed of silk, cotton, linen, or other fabric either oiled or coated with rubber. In all such cases, the permeability has been fairly high so that the loss of gas has been a serious item. This loss is generally increased with age owing to leakage resulting from deterioration and strains from mechanical handling. The commercial problem, therefore, must consider decreasing permeability and improving mechanical construction of the gas bag, as well as decreasing the cost of the gas. Until recently when either because of change of altitude or change of temperature the gas expanded, it was necessary to relieve the pressure by releasing gas which was wasted. The modern Zeppelin practice is to compress any surplus gas and keep it in containers so that it can be again used when needed. The construction of the Zeppelin which provides an air space between the outer covering and the inner ballonets by minimizing changes of temperature, likewise reduces such losses. This intermediate air space, however, introduced a new danger because gas which had escaped from the ballonets became mixed with air and gradually assumed explosive proportions. Only recently has this danger been eliminated by ventilation of the intermediate air space. It has been suggested that this improvement has again permitted the use of anti-air craft guns on top of Zeppelins, although only a couple of years ago their use in that position was discontinued because of some danger not disclosed to the public.

It is obvious that every advance in concentration of strength and energy, every bit of progress in reducing weight without sacrifice of other qualities, brings nearer the day of the commercial dirigible. It has sometimes been reported that the passenger carrying Zeppelins familiar to many Americans in Germany prior to the war were commercially profitable. It is doubtful, however, whether this would be correct without making allowance for government help of one kind or another. Perhaps enough has been said in this rather rambling outline to indicate that the commercial development of dirigibles must depend absolutely upon coöperation of a very far-reaching type. Those who are familiar with work of the Automobile Chamber of Commerce and the Society of Automobile Engineers realize that the lesson they have taught the country is one which must be taught in general, not only for our commercial and industrial welfare, but for the very safety of the nation, and the coöperation which will be necessary to make quick progress in the commercial development of dirigibles should be far more comprehensive than anything that the automobile industry has yet experienced. Suppose, for example, that our national executive should decide that it is a matter of importance for the nation to have dirigibles developed rapidly so that their commercial and hence their military efficiency could be quickly made use of, it would not seem impossible to organize a development committee, for want of a better name, somewhat along the following lines:

Members from:

a. Government. Scientific experts from naval and military departments, Smithsonian Institution, Bureau of Standards, Post Office, Coast Survey, Coast Guard, Council of National Defense, National Research Committee, Government Laboratory recommended by Naval Consulting Board, Weather Bureau.

b. Scientific Organizations. Societies and individuals, colleges and technical schools, geographical and exploration societies, associations of doctors and lawyers.

c. Industries. Metal manufacturers, engineering firms, textile and wood-working concerns, rubber and other industries based upon colloids, scientific instrument makers, chemical industries, motor manufacturers.

d. Commercial Bodies. Chamber of Commerce of the United States, merchants' associations, distributors of light, expensive merchandise, real estate boards.

e. Transportation interests.

f. Sporting and Publicity Bodies. Automobile and aero clubs, hunting and traveling associations, Navy League, National Security League, and patriotic organizations, advertising clubs of the world.

a. The importance of government initiative in this matter cannot be overestimated. While every other important nation in the world is concentrating all of its resources and forces, without exception, under government leadership, our Government on the contrary tends to evade its responsibilities. This is a very serious matter, worthy of the careful study of every thinking American, because it is today an open question whether forty-eight loosely united, almost independent states, without strong Federal government leadership, can compete successfully with other industrial nations, compact and coördinated. It seems especially important by every means possible to urge our Government to show leadership especially in those departments where the necessary ability and organization already exist. Therefore, a small committee representing the best brains and optimism of our naval, military, post-office and other Government departments would be not only a tremendous help, but the psychological effect on the other groups would be decisive.

b. The importance of refining everything from motors to fabrics down to small fractions of 1 per cent involves the most comprehensive use of all of our scientific brains and resources. As many legal questions will arise as air navigation increases, even the lawyers can do their part. It has been stated that air ships have shown remarkable cures of some nervous troubles. With berths, hot meals, electric light and electric heating already possessed by Zeppelins, it is not beyond the limits of possibility to consider aerial sanitaria. The whole effect of air travel upon man must be studied.

c. The astonishing increase of knowledge of the properties of alloys in the past few years leads us to expect still more important discoveries in this field in the near future. The combined resources of our steel and other metal plants, with their highly efficient chemical and physical laboratories, the coöperation of engineering firms, the more scientific investigation of textile methods and products, the better methods of testing and evaluating both wood and metal constructions, all lead to expectation of great progress in those directions. It is known that materials exist which are one hundred times less permeable to hydrogen gas than is rubber as now used, so great possibilities lie ahead through cooperation of the experts and applying the resources of the colloidal industries.

d. The Chamber of Commerce of the United States, with its national affiliations and interests, could well number among its activities the furthering of dirigible development. Everything which tends to facilitate communication between localities tends to the advancement of the nation.

e. As feeders for railways in sparsely settled communities or in locations where railroad building is extremely difficult or expensive, as means for carrying mails and light merchandise in similar country, even as competitor for the automobile where roads are scarce or forests and other obstructions control, in many ways it is conceivable that the dirigible could be placed at the service of mankind.

f. We have passed from the bicycle to the automobile and now are passing from the automobile to the aeroplane; and from the aeroplane to the dirigible is but a short step. This does not mean that any of these mechanisms are losing in usefulness, but on the contrary, each is filling a larger and clearer field of its own. Exploration, traveling for pleasure, even hunting can be carried on by air with marked advantage.

It may seem to some that the end is not worth the means, that the aeroplane will do all that the dirigible can and that the difficulties in the way of developing the dirigible commercially do not warrant the effort. On the other hand, the dirigible has inherent advantages not possessed by the aeroplane. It is quite conceivable that the future will witness a combination of the advantages of dirigible and aeroplane in some compromise craft which will depend partly upon the aeroplane wing and partly upon the gas bag. Such a craft might have less speed and consequently be easier to land. It would have greater bulk and thus be an easier prey to wind and storm than the aeroplane, but it is evident that in one type of craft neither all of the advantages nor all of the disadvantages can be combined. Already the dirigible makes valuable use of planes and the little British "blimo" instead of a car has beneath its gas bag an aeroplane fusilage, so that it can slide along the ground somewhat as an aeroplane can.

Whether or not the dirigible becomes of commercial value, probably depends more upon the United States than any other country. Whether this achievement is recorded to our credit or not may depend upon the national imagination, optism and determination.

*A paper read before the Aviation Congress, New York.

Photos by Press Ill. Service, Inc.

**The 101-inch mirror—note reflection of its maker at the right**

**Preparing to remove the mirror from the grinding machine**

# The Largest Reflecting Telescope in the World

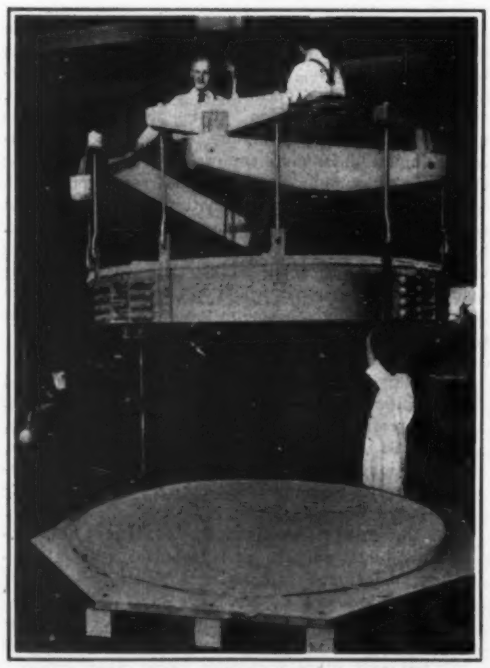
## Making the Great Mirror, and Transporting It Up the Mountain

One of the last steps in the installation of the great reflecting telescope at the Mount Wilson Observatory, in California, the largest instrument of its kind in the world, was the removal of the mirror from the Pasadena plant, where it was ground and figured, to the summit of the mountain, and this was succesfully accomplished on July 1st. This precious piece of glass is 101 inches in diameter, and 12¾ inches thick at the edge, and is said to weigh four and a half tons; and if any accident happened to it it would mean years of delay to the projected instrument, so unusual precautions were taken for its safety on its journey to the top of the mountain, 6,000 feet above sea level.

The order for the disk of glass, from which the mirror was to be formed, was placed with a firm in France in the autumn of 1906, and it arrived in California in 1909, which was not an unusual delay, for it is an exceedingly difficult task to produce a perfect piece of glass of such a large size; but on examination it was found that it contained a number of imperfections, and it was proposed to abandon it. The makers immediately made preparations for another attempt, building a large special furnace for the purpose, which contained a melting pot capable of holding 20 tons of glass; but in spite of their best endeavors several other disks that were cast either showed defects, or were broken in the process of annealing. It was therefore decided to make a trial of the disk first cast and delivered, and in 1910 the work of grinding was commenced, but it was not until 1913 that the processes of forming the mirror had progressed far enough to institute the tests that demonstrated its success.

Great skill and experience is necessary for producing a mirror of this kind, and the making of this mirror was undertaken by Prof. George W. Ritchey, of the Mount Wilson Observatory staff, and to his task he brought a wide range of experience gained in the construction of many kinds of optical instruments, among which may be noted the large 60-inch reflector that has been in successful use in the Observatory for some time. The first operation to be performed on the great disk was to grind its surface to the form of a perfect sphere, after which this was worked into the form of a paraboloid, and this latter operation occupied about one year. Notwithstanding the great amount of time expended in the grinding, polishing and figuring this mirror the depth of the curvature is only about 1¼ inches; and at its center, where the difference is greatest, the depth of the finished paraboloid differs from that of the nearest spherical surface by only one-thousandth of an inch. This gives some idea of the delicacy of the operation of figuring an instrument of this kind. In a general way the power of this new telescope, and the work that may be accomplished by its aid, is given in the following quotation from a publication issued by the Observatory: "To the unaided vision about 5,000 stars would be visible on a clear night in the entire sky. According to a recent estimate by Chapman and Melotte the heavens contain about 219,000,000 stars, brighter than the twentieth magnitude, which are within the range of our 60-inch reflector. If the indications afforded by Chapman's figures can be applied to fainter objects there is reason to hope that a 100-inch telescope would add nearly 100,000,000 still fainter stars, many of them lying beyond the boundary of the universe, as at present known."

Not all of the seven years that have elapsed since the work of grinding this great mirror was commenced was devoted directly to it, for it was also necessary to produce a 60-inch plane mirror for testing the 100-inch mirror. Also there have been prepared two convex mirrors for use with the larger mirror in making observations, one 28¾ inches in diameter and over 6½ inches thick, with a radius of curvature of 28 feet 10¾ inches; and one of 25 inches diameter, with a radius of curvature of about 22 feet 11 inches. The focal length of the large mirror is 42 feet 3½ inches; when used with the larger of the above convex mirrors the equivalent focal length is 150 feet, and with both of the convex mirrors in use the equivalent focus is 251 feet. The dome of the building in which the great telescope is located, and which is shown in the illustration on the first page of this issue, is 100 feet in diameter.



**The mirror, suspended in a clamp, being lowered onto the base of the packing case**

As has been said, the work of grinding and figuring the great mirror was done in the shops of the Observatory in Pasadena, and the greatest care was exercised in preparing and packing it for transportation to the dome that is to house it on the summit of Mount Wilson. These preparations are shown in the accompanying engravings. In one of these illustrations a portion of the protecting padding on the surface of the mirror is thrown back, and the reflections of two of the men standing by are seen in the polished silver surface. The man on the right is Professor Ritchey, who designed the telescope, and produced the mirror, and it is interesting to note that if this illustration is turned upside-down a very good likeness of the Professor is seen.

A complete description of this wonderful instrument would occupy too much space to be given here, but an account of its construction will be found in the Scientific American of August 11th.

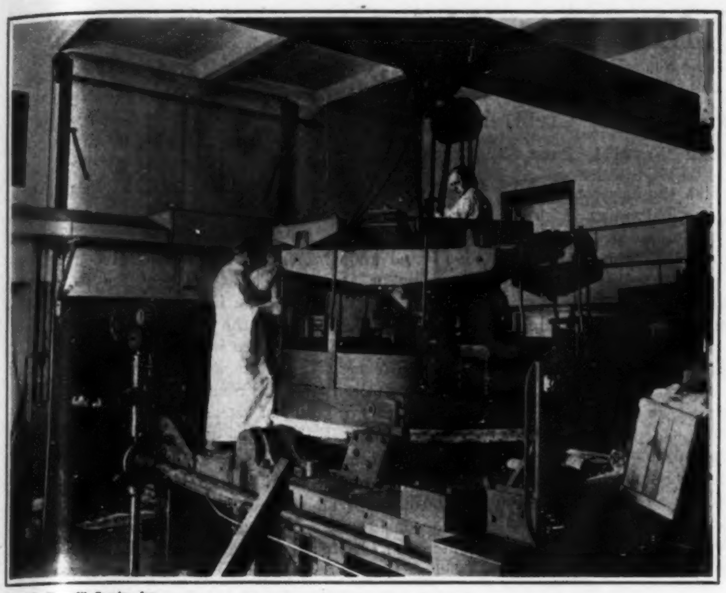
### Road Illumination vs. Glare

The statement has been made that in order to get sufficient road illumination for comfortable and safe driving, a beam of light of such high intensity is required that if this beam of light is directed into the eyes of an approaching driver the glare is so intense that it is highly dangerous in passing. If then it were not possible to so direct the rays of light, that only the road were illuminated, as for example, if a very powerful arc lamp were mounted on the front of the car, a serious state of affairs would exist, and anyone using the highway at night would make himself highly objectionable and dangerous to all of the other users of the highway. If such a state of affairs did exist, it would be necessary to limit the power of headlamps to such a point that the glare produced would not be so great, but that all the users of the road could get by each other, and at the same time they would be able to have enough road illumination to proceed at a slow rate of speed. The question would then be simply one of road illumination versus glare.

If, however, we accept the solution of directing the light toward those portions of the roadway which it is necessary to see, and by keeping strong light intensities away from the pathway which would be followed by the eyes of the drivers of approaching vehicles, the problem becomes more simple. The problem then consists of determining just what light pattern is the best to project, and of furnishing suitable devices with engineering instructions for their use so that the ordinary driver of automobiles can utilize this light distribution on his car. —From a paper read before the Philadelphia Section of the Illuminating Engineering Society by H. T. Gage.

### Use of Barley for War Bread

A standard "war bread" has been in use in France for some time past, but its precise composition has not been made public. This may, however, be subject to modifications, and in this connection it will be of interest to note a recent paper presented to the Academy of Medicine by Profs. Weill and Mouriquand upon the use of barley in such bread. The authors bring out the conditions in which barley can be thus employed to the best advantage as regards nutritive value, and as a result of their researches they find that barley has a nutritive value which comes very close to that of wheat. It is necessary to use whole barley for the outer coating contains nutrition of the first importance.



Photos by Press Ill. Service, Inc.

**Placing the lifting clamp on the mirror**

**The mirror going up the mountain on an auto truck**

## Calorific Value of Gaseous Fuels*

### Methods of Evaluation

The increasing extent to which gaseous fuels are now employed for purposes of power generation, either directly in internal combustion engines or indirectly under steamboilers, renders it useful to consider the laboratory methods by which such fuels can be tested and their heat value gaged.

The calorific value can of course be determined in the bomb calorimeter, but the difficulty of obtaining an accurately measured volume of the gas in the bomb without loss, and the very small volume that can be accommodated for each test, has led to the design and manufacture of special forms of gas calorimeters. These are all based on the same principle—namely, that of burning the gas in air under a steady and uniform pressure in such form of standard burner, and of absorbing the heat generated in a vessel through which a constant and uniform stream of water is flowing. They are thus "flow calorimeters," as opposed to the static condition obtaining in the calorimeters used for solid and liquid fuels.

The chief problems of their design and use are (1) to obtain the required uniformity in the flow of water and gas; and (2), to assure the absorption of the whole of the heat of the combustion gases. The thermometers used must be carefully calibrated, and most exact measurements of the water and gas employed are of course necessary in order to obtain reliable results. The standard of measurement for the calorific value of gases in this country is the British thermal unit, and the results are generally expressed as B.t.u. per cubic foot of gas consumed. In countries where the metric system is adopted, the results are usually expressed as calories per cubic meter, the large (kg.) calorie being employed in place of the small (gramme) calorie. To convert kg. calories per cubic meter into B.t.u. per cubic foot it is necessary to multiply by 0.1123, while to convert B.t.u. per cubic foot into kg. calories per cubic meter the factor is inverted and becomes 8.898. The calculation of the calorific value of the gas is therefore made by multiplying the weight of water expressed in kg. (or lb.) flowing through the calorimeter in a given period of time, by the rise in temperature expressed in degrees C. (or F.) and dividing the product obtained by the volume of gas burned in the same period of time, expressed in cubic meters (or in cubic feet). It is customary to measure the water in a graduated cylinder, but if great accuracy is required it is better to weigh it. In any case the gas volume as measured by a calibrated test-meter reading to the hundredth of a cubic foot, must be corrected to the standard temperature and pressure.

Several different forms of gas calorimeter have been designed, and placed on the market, but two only will be described—the Jünker form and its latest modifications, and that designed specially by Professor Boys, to suit the needs of the London Gas Companies, when they first adopted the calorimetric standard for testing in 1909.

#### Jünker Calorimeter

The earlier form of the Jünker gas-calorimeter suffered from several disadvantages, but in its latest form, as now used in Germany and America, some of these defects have been remedied or modified. Apart from the gas-meter and pressure regulator which are common accessories to all gas-calorimeters, the apparatus consists of a tall cylindrical vessel of sheet copper, holding about 1,700 cc. of water. This vessel surrounds a combustion chamber within which an ordinary Bunsen burner is placed, and is connected by flexible tubing with the gas pressure regulator. The flow of gas should be regulated to yield about 1,200 calories of heat per hour, this being the best rate of absorption for the instrument. A throttle valve is placed on the waste discharge pipe of the calorimeter, and by means of this the amount of air passing into and through the instrument can be regulated. The water supply takes place through a tank, with an overflow, the height of which can be adjusted to give the head required. The main supply to this tank should be capable of providing up to three liters per minute, and the overflow pipe is so arranged that note can be taken at once if the flow through it ceases. The flexible tube which conveys the water away from the calorimeter, after abstraction of the heat of the combustion gases, is so connected that the water may be directed into the measuring vessel instantaneously without splashing or loss. A small measuring vessel is also provided for measuring the condensation water produced by the combustion of the hydrogen in the gas under examination. Two standardized thermometers are provided, graduated from 0 deg. to 50 deg. C. (each degree divided into tenths) for taking the temperature of the inlet and outlet water, and in the latest instruments these are arranged on the same level.

When taking readings with this instrument, a position of equilibrium is allowed to set in, and after this stage is reached the moment the pointer on the gas-measuring meter passes the vertical number on the dial the water flowing from the outlet of the calorimeter is switched into the measuring vessel, and the amount collected during one or more revolutions of the meter pointer is recorded, together with the time. During this period, which may be from one to five minutes, the inlet and outlet thermometers are read at regular intervals, and the average difference in temperature is used for calculating the test results.

#### Boys' Calorimeter

Owing to the general adoption of gas for domestic heating and of the incandescent mantle for illuminating purposes, many of the leading gas companies and undertakings in the United Kingdom have obtained legal sanction during the last few years for the change from the photometric to the calorific standard of value, and the Boys' calorimeter is now adopted as the standard instrument for testing the quality of the gas supplied to the public in all large towns. The instrument consists essentially of an outer vessel of sheet brass, with a central chimney of thick sheet copper. Attached to the lid of this vessel is a brass box, which carries the outflow pipe and acts as an equalizing chamber for the water flowing through the calorimeter. The lower or pendant portion of the box is kept cool by circulating water, and is connected at its lowest point by a union to six turns or spirals of copper pipe, similar to that used for motor-car radiators. A helix of copper wire is wound round this pipe and sweated on to it, in order to accelerate its action in absorbing the heat of the gases. A second pipe and helix of similar form surrounds the inner one, and is connected to it at the lower end by a union. This second spiral terminates at its upper end in a block, to which the inlet water-box and thermometer-holder are secured. Between the outer and inner coils which carry the water is placed a brattice made of thin sheet brass and filled with cork dust. This acts as a heat-insulator between the two coils. A cylindrical wall of thin sheet brass is secured to the lid, and serves to protect the coils of copper pipe with their surrounding helices of wire from injury when these are removed from the calorimeter for cleaning purposes. The two thermometers for reading the water temperatures, and a third which may be added for reading the temperature of the outer air, are all near together and at the same level. The lid may be turned round into any position relative to the gas inlet and condensed water-drip that may be convenient for observation, and the inlet and outlet-water boxes may themselves be turned so that their branch tubes point in any direction. The instrument is convenient also in its small height, the thermometers being comfortably read when the instrument is standing on an ordinary table.

In order to prevent corrosion of the metal surfaces by the continued soaking action of very dilute sulphuric acid and dissolved oxygen, the whole of the coil system can be lifted up out of the vessel when the measurements have been made and placed in a jar containing a very dilute solution of carbonate of soda.

The water contents of the coil and equalizing box of the Boys' instrument are only 300 cc. and of the vessel up to the overflow 400 cc. The designer justifies his inversion of the usual arrangement of small gas space and large water space by stating that the latter leads to irregular outlet temperature. In his opinion the gases should have sufficient space to pass slowly through the calorimeter, while the water should be taken rapidly through every channel strictly in series, with the complete avoidance of parallel flow. The small water pipe used in his design, fortified with heat-collecting ribs or wires, carries sufficient water to absorb the whole of the heat present in the hot gases. Tests indicate that the form of construction yields variations only of .01 or .02 deg. C., with a total rise of 24 deg. C., and that in form 10 to 15 minutes after lighting up the calorimeter is giving uniform readings.

*London *Times* Engineering Supplement.

## An Agile Tahr Family

There is no more interesting sight in the New York Zoological Park than the antics of the tahrs. These Himalayan goats, that are quartered on Mountain Sheep Hill, have been provided with a series of steps that lead to the lower branches of an enormous tree—an oak, with wide-spreading horizontal branches. For months the gambols of these mountaineers on the large branches of the oak have provided a spectacular novelty. Of late the tahrs have become more daring, and have been ascending to boughs about twenty feet from the ground. Their movements are so agile, yet erratic, that we have at times worried about a possible fall and serious injury. It appears that these animals have studied carefully the possibilities in leaping to higher branches, and from thence safely descending. Anxious visitors often seek a keeper to have him assist an animal in descending, and upon returning are usually amazed, after patient watching, to observe the object of their solicitude rapidly descend the tree for a distance of six or eight feet, alight upon a lower branch, then calmly survey his corral-mates that may be frisking along the rocky ledges far below.—*Bulletin.*

# The Nature of Matter—II.*

## This is Not a Universe of Dead Atoms, But of Active Energy

By J. C. Whitehorn, Doane College, Crete, Neb.

Continued from Scientific American Supplement No. 2171, Page 83, August 11, 1917

Now, it is quite evident that the emission of these constituent parts of the atom, the alpha and beta particles, would result in a transformation of the atom. And so it does. All radio-active elements undergo these transformations. Radium furnishes a typical example. It was stated above that radium gives off alpha, beta and gamma rays. This is not strictly accurate, for it has been found that these rays arise from a mixture of radium and some of its transformation products. Pure radium emits only alpha particles. The expulsion of an alpha particle transforms the radium atom into the atom of a new element, called radium emanation. This transformation takes place by geometrical progression at the rate of one-half in 2,000 years.[9] That is to say, one-half of a given quantity of radium will be transformed into radium emanation in 2,000 years, one-half of the remainder in another 2,000 years, etc. Theoretically this would mean that there would always be a residue of radium, but practically the radium would be completely transformed in about 100,000 years.

A moment's consideration will show that radium must be produced from some other substance, else the supply would long ago have been exhausted. Rutherford has shown that radium is a product of ionium and he has traced its transformations as far back as uranium. The whole series of transformations have been worked out from uranium to an end product thought to be lead. The following table gives the series:[10]

| Element | Ur | $UrX_1$ | $UrX_2$ | Ur2 | Io | Ra | Ra Eman | Ra A |
|---|---|---|---|---|---|---|---|---|
| Emitted Particle | $\alpha$ | $\beta$ | $\beta$ | $\alpha$ | $\alpha$ | $\alpha$ | $\alpha$ | $\alpha$ |
| Half-Period | $5\times10^9$ yrs. | 24.6 days | 1.14 min. | $10^6$ yrs. | $2\times10^5$ yrs. | 2000 yrs. | 3.85 days | 3.0 min. |

| Element | Ra B | Ra $C_1$ | Ra $C_2$ | Ra D | Ra E | RaF Pol | Lead (?) |
|---|---|---|---|---|---|---|---|
| Emitted Particle | $\beta$ | $\alpha$ | $\beta$ | $\beta$ | $\beta$ | $\alpha$ | |
| Half-Period | 26.8 min. | 19.6 min. | 1.38 min. | 16.5 yrs. | 5 days | 136 days | |

If we trace the story of this changing atom, we find it first as the atom of a fairly stable element uranium. But this stable atom in time expels an alpha particle and by a rapid series of further expulsions and rearrangements it is transformed into the atom of an element called Uranium 2. This is also a fairly stable element, but in time this atom also expels an alpha particle and becomes ionuim. The atom of ionium gives off another alpha particle and becomes radium. It then undergoes a remarkable series of comparatively rapid changes, becoming at last the stable element lead. This, in bare outline, is the tumultuous and kaleidoscopic history of an atom.

This discovery by Rutherford of the actual transformations of real atoms has revolutionised scientific thought. The corpuscular theory has again been empirically confirmed, and so emphatically that widespread acceptance has been secured. The atom seems no longer the unchanging and indivisible piece of a material entity we had once thought. It appears now as a microcosm—a universe of energy in motion, with inner possibilities of disintegration and transformation.

There is, however, a difficulty which some have felt in accepting this theory that matter is essentially only energy in motion. It will be recalled that in the beginning of this discussion attention was directed to the fact that the two great empirical supports for the metaphysical idea of a material entity were the properties of extension and mass. Now, the advocates of the electron theory have shown very conclusively that mass is altogether due to disembodied charges of electricity in motion, and hence that no material entity need be postulated to account for mass. But to some a theory which supposes everything to be energy seems insufficient to account for the fact that bodies are hard and solid and actually occupy space. They ask, "If there be no material entity and if energy in motion be the only *stuff* of which the world is made, how comes this property of extension? How can energy fill space?"

No entirely satisfactory answer has yet been found, but the electron theory hints at a solution. The electron or corpuscle is a disembodied unit charge of negative electricity. It is thought that this electricity does not occur in the form of a geometrical solid of definite size and with definite boundaries. Rather it is believed that the electrical energy of which the electron is composed is distributed through space, extending infinitely in all directions. Thus, as J. J. Thomson says, "each corpuscle may be said to extend throughout the universe."[11] Actually, then, the electron more truly "occupies space" than did the old hypothetical material entity, for the "extension" of an electron is infinite.

But if this be true, as it is, beyond reasonable doubt, then every electron interpenetrates every other electron, which appears to be a direct contradiction of the law of the impenetrability of matter. This apparent contradiction can, however, be reconciled in a manner which throws much light upon the problem of extension.

While every electron extends throughout the universe, yet by far the greater part of the electrical energy of which it is composed is concentrated in a very small space about a point. This sphere of great concentration is exceedingly small, its radius being about $10^{-13}$ cm.[12] Outside this volume of great concentration, the amount of electrical force is negligible. Hence the mutual repulsion of electrons is appreciable only when the distances between their centers is very small. But when their proximity is exceedingly close, as in an atom composed of several electrons, then the force of repulsion is very great. Thus, while it is true that in an atom of one electron the mutual attraction between the nucleus and the electron pulls their centers together until they are at the same point, yet in an atom of more than one electron, the centers of the several electrons, when they come close together about the nucleus, will exert a great repulsion upon each other, with the result that they will *not* come together with their centers at the center of the nucleus but will, instead, group themselves about this center. At equilibrium the electrons will be ranged in a spherical surface with the center of the nucleus as its center, or if the number be large, in several such spherical surfaces, one within the other.

Now, such a system of electrons, held in their positions about the nucleus by such powerful forces would very plainly resist any attempt to distort its shape. Although it might take up additional electrons or give off extra electrons, thereby changing its constitution and hence its structure, yet any attempt to distort its structure without so changing its constitution would be powerfully resisted. Consequently the atom would be practically impenetrable.

Now, atoms which lack their full quota of electrons attract atoms which have more than their full quota. Because of these mutual attractions, atoms come together and build up molecules. But here too the forces of repulsion prevent the atoms from actually coinciding with each other, so that the molecule is larger than the separate atoms of which it is composed. The molecule is thus a system of atoms which is usually simple but sometimes, as in the proteins, exceedingly complex. The molecule is of course susceptible to forces tending to bring about a change in its constitution. But any effort to change its form without changing its constitution is powerfully resisted, just as in the atom. Hence the molecule, too, is practically impenetrable.

Now, intermolecular forces attract molecules together. If a sufficiently large number of molecules are brought together, a body of appreciable size is formed, one which can be directly perceived by the senses. The molecules may thus be so strongly held together that their relative positions can be changed only with great difficulty. According as this difficulty is of one kind or another, we say that the body is hard, or has great tensile strength or offers a great resistance to shear stresses or to compression. In other cases, as of gases, the intermolecular forces seem to be small, and such substances offer very little resistance to a change of form. Thus, bodies of appreciable size while offering some resistance to a penetrative force, are not always "impenetrable," in fact never so in that sense of "impenetrable" which means impossible of penetration.

It has been shown, however, by the preceding discussion of electrons, atoms and molecules, that the *stuff* of which bodies are made is impenetrable in the sense that no two molecules or atoms will occupy the same space at the same time. Thus we have an explanation of the "impenetrability of matter" in terms of the electron theory.

The above discussion of the property of extension shows that impenetrability of matter, which is the empirical basis for the idea of extension, is an outcome of the play of attractive and repulsive forces, and is therefore a derivative of energy. These considerations show further that if an "absolute extension," other than the one based upon impenetrability, be insisted upon, then electrons or structures built of electrons possess this property of extension in an infinite degree, for an electron extends throughout the universe. We can therefore conclude that *no hypothesis of a material entity is necessary to account for extension*, because *energy itself*, when organized in electrons, atoms and molecules, *possesses* this property of *extension*.

The whole of the foregoing discussion of matter and its constitution has shown that a theory which supposes matter to be but a form of organized energy is sufficient to account for all the phenomena of matter which we have considered, including the properties of extension and mass. In fact, this theory can not only be reconciled with all known phenomena but it also gives a more simple and comprehensive explanation than any other theory and, what is perhaps most valuable of all, it explains many phenomena which were hitherto inexplicable. For these reasons the scientific world is accepting the electron theory of matter.

With an insight illuminated and clarified by this hypothesis we realize now the intricacy and complexity of the inner constitution of the atom and the enormous forces locked within it. But this discovery has thus far failed of any great *practical* application. The forces in the atom are not available for human use. Man has thus far been unable to unlock this enormous store of energy. And yet, even though there have been no direct utilitarian results, this electron theory has given us a means by which to solve many of the knotty problems of science. It has illuminated the whole field of natural phenomena and has thus increased our mastery of the world.

This theory has also shed much light upon philosophy in that it has aided us to a truer understanding of the universe. For now we see, with clearer light than before, the weakness and folly of a materialistic philosophy. We know now that *matter* is not an ultimate entity.

If we revert now to the early part of this discussion, we shall find that it began as an inquiry into the nature of reality. We have inquired more particularly into the nature of that phase of reality commonly known as matter. We have questioned the metaphysical assumption of a material entity. We have suggested that the need for this material entity is a psychological one, arising from the tendency of unreflective thought to seize upon the persistent and universal properties of extension and mass as indications of a substance or matter which lies back of and gives support to the less persistent properties. We have taken up at great length a consideration of mass and extension and have found that, far from being primordial and original properties of a material entity, they are instead derivatives of two most non-material things, energy and motion.

We have thus, by a course of scientific reasoning, come to the conclusion that this is not a universe of dead atoms propelled by blind force but a universe of active energy.

It seems to the writer that in this conclusion lies the possibility of a definite, thorough and complete reconciliation of Science, Theology and Philosophy. It is unfortunately true that in some cases the very opposite has happened. Scientists brazenly declare that by means of this theory they have invaded the camp of theology and have stolen its very holy of holies. Theologs loudly declaim that Science, in accepting this hypothesis, has destroyed its own foundation and has given up its materialism for a God; while Philosophers have taken this latest revolution in thought as evidence of the lack of reliability and security in all our knowledge. Such is the attitude of some of our more radical and over-enthusiastic Scientists, Theologs and Philosophers. But the student of Science who combines with his study some measure of devotion and contemplation; the devotee of Religion who tempers his spiritual emotion with logic and deep thought; the seeker after a true Philosophy who holds himself close to empirical knowledge and yet gives his emotions a rightful place—all these, I believe, can find in this new conception of a universe of active energy a more logical and comprehensive rationality, a deeper and richer spiritual meaning, and a grander and nobler plan. Thus may all partial views be wrought into a truer and more complete understanding of the universe as being, all in one, logical, purposeful and sublime.

*Republished from *Popular Astronomy*.

[9] Rutherford, p. 124. (Boltwood gives ½ period of Ra as 1700 years.)

[10] Rutherford, p. 124 (½ of $RaC_1$ and $RaC_2$ as given in Duff-McClung, p. 518.)

[11] Thomson, p. 34.

[12] Thomson, p. 34.

## The Problem of Cross-Atlantic Flying*

By L. Blinn Desbleds

One of the first, if not the first commercial application of long-range aircraft, will be the carrying of mails and of light articles, whenever speed is a matter of consequence. This by itself would not, however, be of such moment as to cause great losses or uneasiness to the shipping industry; but mails contain, among other things, business letters, soliciting orders, catalogs, plans and drawings of machinery which may be required for the development of new countries, letters of credit and legal documents which are necessary for the carrying out of new undertakings; in short, it may be said that modern commerce could not exist without correspondence. In fact, I do not think one would be far wrong in taking it as an axiom that the commerce of the country can be measured by the bulk of its correspondence. And, from this axiom, it would follow that whatever factor influences the correspondence of an industrial must, of necessity, influence its commerce.

Some may, perhaps, at first be inclined to conclude that, granted that aircraft will, in the future, take the place of mail boats, there would only be a gradual transference of the mail service from steamers to aircraft, and that the bulk of foreign correspondence and its consequent influence upon the commerce and shipping of this country would be unaffected by such a transference. Such a conclusion would be erroneous for two reasons.

In the first place, the speed of aircraft is much greater than that of surface vessels. The considerable difference in the speed of aircraft and of watercraft would bring about a greatly increased exchange of correspondence between distant countries than is now possible, and this accelerated rate of exchange of correspondence would in time react upon the commerce between such countries, and, consequently, upon their shipping.

In the light of such reasoning it is at once apparent, therefore, that the commerce and shipping of a country must profit considerably by the advent of aircraft. To this conclusion a proviso must, however, be added. It is that British commerce and shipping would profit by the advent of mail-carrying aircraft only if the mail-carrying business of the air is in British hands. If, after the war, the monopoly of aerial correspondence is left to the Germans, then it would naturally follow that the advantages derived from such correspondence would go to their commerce and shipping.

I have used the word "monopoly" advisedly, for at the present moment the Germans alone possess aircraft that could be employed for the commercial purposes to which allusion has been made; and it is betraying no secret to say that this country does not yet possess any aircarft having anything approaching the commercial capabilities of the German Zeppelins.

Unless a most serious and concentrated effort is made to wipe out our present disadvantage in the matter of long-range aircraft, we shall, when peace is concluded, find ourselves extremely handicapped in carrying out the commercial war which, it is agreed in every quarter, will immediately follow the conclusion of peace.

I hope that, in these few words, I have made clear the importance of aircraft to the future of British shipping; and I would venture to suggest to the members of this Institution that they should consider the subject, not from the theoretical or academic, but from the absolutely practical point of view, and that they should immediately consider the best steps to be taken to grapple with a very serious position.

In proceeding I shall endeavor to show, with all the clearness at my command, why in the present state of development of aeronautical science the aeroplane cannot, for some time to come, be considered as a competitor of the airship for long distance flights, such as the crossing of the Atlantic, and to indicate definitely the lines along which aeroplanes must be developed so that they may have an increased radius of action.

It seems to me that with reference to navigation the majority of British airmen are, as regards the best utilization of their machines, groping in the dark for the lack of exact scientific knowledge concerning their aeroplanes. In the course of this paper you will, I think, appreciate the full force of this remark, and you will then, no doubt, agree that the Royal Flying Corps and the Royal Naval Air Service would be still further improved if their members had, besides their bravery, coolness, and adaptability, a truly scientific knowledge of their machines and of the laws relating to their employment for maximum results. As it has recently been announced that a professor of meteorology has been attached to the Royal Flying Corps, it is to be hoped that this important and most useful appointment will be quickly followed by the just as important, and just as useful, appointment of one or more professors of practical aerial navigation to our air services.

*Abridged from a paper presented before the Institution of Engineers and Shipbuilders in Scotland.

It has been said, and with truth, that in the case of aeroplanes, the development of a particular quality is always attended by the development of a defect. In designing aeroplanes for particular purposes, as well as in their employment, a continuous compromise has to be made between a number of conflicting coefficients. In fact, the degree of adaptability of an aeroplane for a given function always depends upon the degree of success in compromising the different conflicting factors influencing the problem. Thus it is, for example, that, in designing a long-range aeroplane, there is a conflict between the useful weight and the deadweight. If the deadweight is sacrificed to the useful weight, then the range of the aeroplane is increased from the fact that it can take on board more motor fuel, thus enabling the engines to work for a longer time. When designing an aeroplane for maximum range of flight one is, therefore, very much tempted to cut down, to the extreme limit, the deadweight of the machine; but the reduction in the deadweight of an aeroplane of given type cannot go beyond a certain limit, and must be in accordance with rules relating to the strength of the materials employed in its construction. Also, from the very fact that a long-range aeroplane is subjected to more continuous strains than a short-range one, and that, besides, in a long journey, the machine may have to contend with stronger or more frequent gusts than in one of short duration, the long-range aeroplane must, as regards strength, possess a factor of safety at least as great and, if possible, greater than one destined for short-range flights. Thus it is found that in carrying out the compromise between the deadweight and the useful weight of an aeroplane of a given type the designer, for consideration of strength, is prevented by strict laws from cutting down the deadweight beyond a certain limit which, in the present system of aircraft construction, is very quickly reached. Indeed, it can be proved that in the present state of development of aerodynamical science, and with the present methods of construction, an aeroplane which is made to lift a useful weight greater than one ton, in useful load and fuel, does not possess as regards strength a sufficient factor of safety.

The conflict between the two factors, useful weight and deadweight which is settled, as already seen, by strict engineering laws relating to strength of materials is only one example of how a compromise is reached between a number of factors affecting aeroplane design and utilization.

Experience in the employment of aeroplanes has now shown that a speed of 90 kilometers per hour (55.9 miles per hour) is a minimum below which safety in flight, especially a long-range one, is rather precarious.

The efficiency of a propelling plant suited to the aeroplane on which it is mounted, lies between 75 and 80 per cent. An efficiency of 78 per cent is a normal figure.

Maximum-range flight depends upon two circumstances:

(a) The designing and construction of a machine in which the different range-influencing coefficients are thoroughly studied.

(b) The flying of such a machine in a thoroughly scientific manner.

An aeroplane, as at present conceived and constructed, cannot rise if the useful weight is greater than 1,000 kg. (about one ton).

The following figures, however, relate to one of the now numerous projects for flying the Atlantic:

| | |
|---|---|
| 4 motors of 100 h.p. each | 1680 kg. |
| Fuel, lubricating oil, provisions, etc. | 4200 kg. |
| Crew of 10 men | 700 kg. |
| Weight of bare aeroplane | 2420 kg. |
| | 9000 kg. |

The useful weight being 4,900 kg.

This weight of 4,900 kg. is about five times the useful weight which any aeroplane, with the present aerodynamical efficiency, and with existing methods of construction, could lift with safety as regards strength.

How is it, then, that this project of Atlantic flying has been considered capable of realization? It is simply because the machine which has been proposed to realize it would have a factor of safety much below the one which has been recognized as absolutely necessary for flying in weather at all gusty. In fact, the amount of useful weight lifted is found to vary inversely as the cube of the factor of safety. In other words, if the factor of safety of an aeroplane is halved, the useful weight could be eight times as great. An aeroplane with a factor of safety lower than the present one would not, however, present the degree of reliability or safety which aircraft employed for commercial purposes must necessarily possess.

The aeroplanes which are now used for military purposes have a factor of safety of 6, and, taking into account the risks, as regards induced stresses to which a long-range aeroplane would be submitted, this factor of safety can, by no means, be considered a high one. In short, it may be concluded that the project of a cross-Atlantic flight by aeroplane could now be realized only as a sporting feat by a pilot who would be prepared to take enormous risks. With existing types of machines it is only possible by a reduction of the factor of safety. So long as the range of an aeroplane is obtained to the detriment of safety, the machine cannot be considered as a commercial means of locomotion for that range.

In conclusion, I may say that in this paper I have been able to consider only a small aspect of the problem of cross-Atlantic flying, which, for complete solution, demands not only a study of the aerodynamics and strength of aeroplanes, but also a large number of questions relating to the internal-combustion engine, meteorology, choice of routes, navigation, the provision for special instruments, and numberless other items of importance.

## Electric Conductors

Electric cables are used for a great many purposes, such as the transmission of electric power, the conduction of telephonic and telegraphic currents, etc. In some cases a cable carries a great many separate currents, and in some cases only a single current. The use of a cable in the transmission of a single current is in general restricted to the cases where the current is large. This requires a large conductor, which for practical reasons is stranded. It may be either a single group of solid wires, or it may have a more complex structure. A seven-strand cable may be a single conductor made up of seven solid wires, or a single conductor made up of seven groups of wires, or a combination of seven conductors insulated from one another. In the latter case, each of the seven strands may be either solid or itself stranded. When one of the strands of a conductor is composed of more than one wire, each element of the strand is also called a strand. Stranded conductors are very commonly formed of concentric strands, which consist of a central core surrounded by one or more layers of helically laid wires. If used as a completed cable, such a conductor is called a concentric-lay cable. Such a group may be combined with others in the same way in which the wires are combined in the group, thus forming a concentric strand composed of elements each of which is a concentric strand. If a concentric strand so formed is used as a completed cable, it is known as a rope-lay cable.

In the long-distance transmission of power, overhead bare cables of copper or aluminum are extensively used. For underground conduit transmission, cables are heavily insulated and protected by a covering of lead. The insulation may be rubber, varnished cambric, paper, or special compounds. Single-conductor cables of this kind are frequently used for direct current mains. For single-phase alternating service duplex cables are in considerable use. Flat twin cables are most convenient and cheapest where the cable is not unusually large. For alternating currents, two-conductor and three-conductor concentric cables are in great favor. Cables that are to be buried in the earth or used under water have a jute and asphalt covering over the lead, and over that an armor of steel wires or band steel.

Telephone and telegraph cables consist of many wires, each separately insulated with paper, fiber, or rubber, the whole having a light insulating wrapping and a lead sheath. The size of the wires used is more or less standardized, so the size of the cable is roughly indicated when the number of wires is stated, as *e.g.*, when one speaks of a 200-conductor cable. In a telephone cable the wires are twisted together in pairs.

There are, of course, many special kinds of electric cables, for which trade names have been adopted according to their construction or uses. This holds true also of smaller electric conductors, to which the term "cable" does not apply. The smaller conductors are usually either single wires, stranded wires, or cords. There is a great range of flexibility and of kind of insulation in the various divisions, such as magnet wire, heater cord, lamp cord, etc. The twisted pair is used with many portable electric devices.—Circular 37, U. S. Bureau of Standards.

## Removal of Rust from Iron Plates

A finely crushed mixture of 2 parts of sodium bisulphate and 1 of common salt is wetted until cohesive, applied to the iron plate, and left on till the plate is clean. The action is much more rapid if the plate is scraped every 2 to 3 hours and scrubbed with a wire brush and water, and the treatment repeated. When clean the plate is well washed, finally with an alkaline solution, and dried quickly.—*Note in Jour. Soc. Chem. Ind.* on an article by F. W. Watson *in J. Chem. Met., and Min. Soc., S. Africa.*

# Dropping Bombs From Aeroplanes

## An Ingenious Instrument Employed by the Germans

By Jean-Abel Lefrance

Last February a French aviator, Capt. Guynemer, succeeded in bringing down inside the French lines, one of a raiding squad of 20 German bombarding planes of the newest type manufactured by the Gotha Wagonen Fabrik. A peculiarly interesting feature was the Goerz sighting telescope or range-finder, designed to facilitate the taking of correct aim at objects to be bombarded. A careful study of this, with a discussion of the laws governing the dropping of bombs on definite objects, appears in *La Nature* (Paris), together with the accompanying diagrams.

Any projectile dropped from a height is subject, of course, to two constant forces, the resistance of the air and the acceleration due to gravity. Its trajectory is a vertical line from the point of discharge A to the striking point, B (Fig. 1). If the bomb be dropped from an airship in motion it will have an initial speed equal to and in the same direction as that of the latter. This new force is compounded with the two former and the result is the curved trajectory A C.

If this bomb, having a given initial velocity, is dropped into a layer of air in motion, that is, into the wind, it is acted on by the latter, and is said to undergo "drift." If the wind is at the back the trajectory is lengthened as in A D; if there is a head wind the trajectory will be shortened as in A E.

If the bomb be dropped from an avion which the strength of the wind causes to be stationary with respect to the ground; *i. e.*, when the velocity of the wind is exactly equal to that of the avion and in the opposite direction, the projectile will have no initial velocity and the curve of its trajectory will be a function solely of the drift produced by the wind, as in A b; it will therefore fall to the rear of the point of departure. This latter case, however, is exceedingly rare, since it presupposes a wind of 120 to 150 kilometers per hour; but this is a gale too high to permit the sending up of aviators.

These trajectories being given, the angle of aiming will be the angle formed by the vertical line A V at the point of departure A with the straight line joining this point A with the striking point O, *i.e.*, the angle VAO.

Since these trajectories are curves the height of the avion above the object aimed at is an element which modifies the value of the trajectory. Since the wind causes drift this drift will vary with the form of the projectile and with the velocity of the fall. Here we have two elements which are constant for each type of bomb.

To resume, the trajectory of a bomb discharged from an avion is the resultant of the following forces:

Weight
Form } Elements constant for a given type of bomb
Drift

Speed of avion in wind { Considered as a constant for a given type of avion

OTHER ELEMENTS

Height of shot
Initial speed of bomb, *i.e.*, of avion with respect to ground } Vavariable elements
Velocity of head wind

Of these three principal variable elements which it is necessary to know for each case of bombardment, one of them, the velocity of the head wind, can be immediately deduced when the velocity of the avion with reference to the earth is known, since this velocity of the wind is the difference between the velocity of the avion with respect to the earth and its normal velocity in the wind, an element which is fixed for a given type of avion.

Take an avion having a normal speed of 150 km. per hour; if it is only going 100 km. per hour with reference to the earth, then it is flying against a head wind of 50 km. per hour. Hence it is only necessary to know the height of the avion and the initial speed of the bomb to determine a trajectory. This method of calculating trajectories seeks to base itself on science in order to obtain a mathematical precision in its results. Unfortunately it is based upon a probable knowledge of atmospheric conditions, which are essentially capricious. Particularly, the speed of the wind at the height of the avion is taken into account, *e.g.*, at 4,000 meters, but it is supposed that this remains unmodified down to the ground, which is rarely the case in reality. It may also be that starting from 3,000 meters the wind changes its direction so much that the best calculations, the best telescopes, and the best bombardiers, are unable to secure a correct aim, so that some authorities despair of ever being able to get results in aerial bombardment comparable to the efforts made.

*Goerz Range-Finder.*—This is certainly the best and most highly perfected effort of German science to find means of destroying railroads, factories, and populations outside the range of their big guns. It consists of

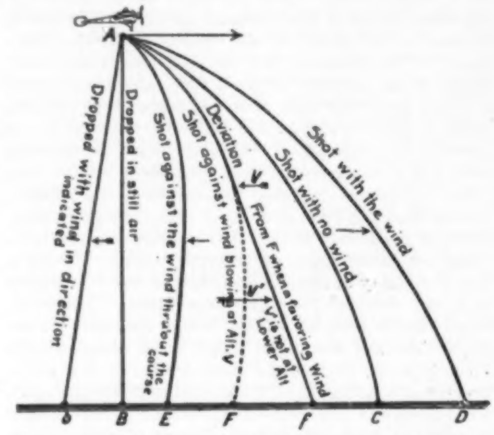



**Fig. 1. Trajectory of a bomb falling from an aeroplane as affected by the direction of the wind**

a telescope about one meter long; mounted on a universal joint, it can be oriented in every direction and kept strictly vertical whatever be the position of the avion (Fig. 2). The accompanying diagram (Fig. 3)

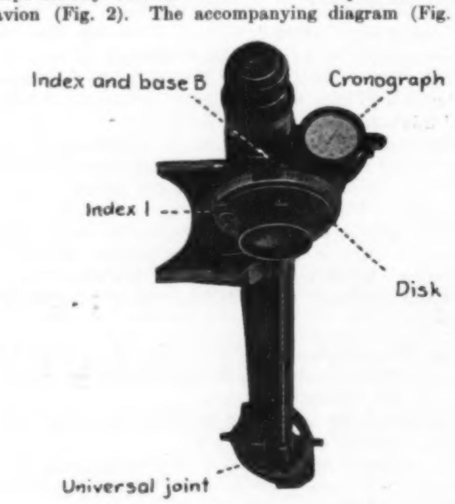



**Fig. 2. The Goerz range-finder**

shows the ensemble of the optical system; the field obtained is 500/1000 and the enlargement is 1.5.

At the base of this telescope is a prism mounted on a pivot and controlled by a graduated disk. The tele-

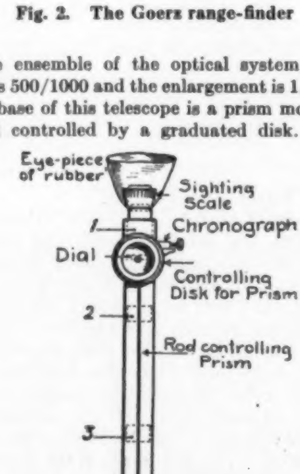



**Fig. 3. Diagram showing construction of the Goerz range-finder**

scope remaining vertical the play of the prism permits the visual ray to be inclined a number of degrees corresponding to the graduations of the disk.

On this disk are two indexes, one corresponding to the vertical speed, or dead point of the range-finder and the other to the vision of 22° 30′. Another index serves as a basis; it is fixed on the body of the range-finder. At 0° the marksman sees the ground along the vertical (Fig. 4); at 20° the inclination of the visual ray is 20° in front of the avion (Fig. 5); at 5° the inclination is 5° behind the avion (Fig. 6).

A small index is movable upon the disk but can be made solid with it by means of a little detent. This index once fixed before a graduation of the disk, after passing the dead point falls into a small notch, and thus informs the gunner that he sees the ground according to the inclination which he had marked with this index; this is disengaged by a slightly stronger pressure of the hand.

In the body of the telescope is a spirit level. The edges of the air bubble are refracted in such manner that they appear in the form of a black circle which serves as a sighting center for the telescope. In the course of all his range finding operations the gunner must keep this bubble in the center of the ocular, which will keep the range finder vertical no matter what the inclination of the avion is.

The universal joint permits the finder to incline freely from right to left or from front to rear, but when it revolves around its vertical axis, *i.e.*, when the visual ray, instead of being directed in front of or behind the avion, is directed to the right or the left of the route followed, the finder acts upon a route corrector. This consists of an electric device. Resistances act upon a very sensitive galvanometer placed in front of the pilot and indicate to him how to correct his route in order to make it pass exactly above the object to be bombarded.

*Method.*—There are only a few of the elements constituting a trajectory which can differ in the course of each bombardment: the height of the avion above the object, the initial velocity of the bomb, the speed of the wind. The German method of the Goerz finder enables a calculation of these three elements to be made.

1. The height is obtained by substracting from the altitude range shown on the altimeter of the avion the altitude of the object bombarded; *e.g.*, if the avion is flying at 4,200 meters above sea-level, and if the factory to be bombarded is 200 meters, then the height to be reckoned with will be 4,200—200—4,000 meters.

This method, moreover, is subject merely to very slight errors where high altitudes are in question. Example: at 90 km. an error of altitude of 500 meters for an avion at 4,000 meters, corresponds to an error of only 25 meters at the ground level (Fig. 7).

2. *Initial Velocity of the Bomb.*—In reality this is the speed of the bomb with reference to the ground. This element is the most difficult to know, because it varies with the velocity of the wind, which is in a state of perpetual instability. If an avion possesses a speed of 150 km. and the wind is blowing at the rate of 50 km., then with a following wind the avion will travel at 200 km. per hour, while with a head wind it will go only 100. This difference of speed considerably modifies the trajectories as can readily be seen by examining the curves in Fig. 7, in which the avion is going 120 and 60 km. per hour respectively. In place of being simply added or subtracted this speed of the wind and speed of the avion may be compounded if the avion receives the wind for example ¾ to the rear (175 km. per hour) or three quarters head on (125 km. per hour).

In principle, to simplify the calculations, the avion should bombard with the wind head on, *i.e.*, with the speed as much reduced as possible. To determine this kilometric speed of the avion we calculate the time required by a fixed point on the ground O to traverse an angle fixed at 45° or 22° 30′.

It is easy to see by the figure that the time required by an avion to find the range of the same point successively first with an angle of 22° 50′ and then vertically, is proportional to the speed of the avion with respect to the earth. A value in seconds is obtained.

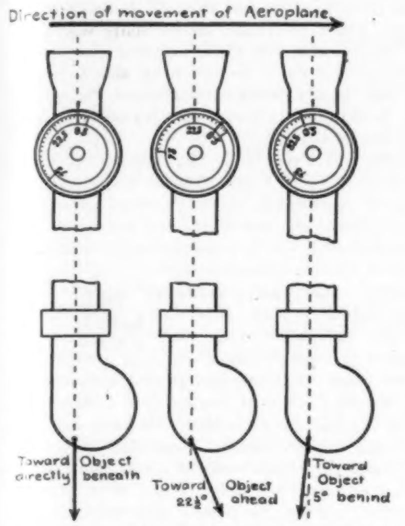
A previously prepared table will indicate that if, the avion being at an altitude of 4,000 meters, a point on the ground takes 36 seconds to pass through an angle of 22° 30′, then the avion is going 100 km. per hour, with reference to the earth; if the point takes only 18 seconds to pass through the same angle the avion is going 200

km. per hour. This value is the initial horizontal speed of the bomb.

3. Morevoer, it is known that avions of the Gotha type have 150 km. per hour speed when the motors are revolving at their usual velocity; if the preceding range finding shows the speed at the ground to be only 100 km. per hour, the obvious deduction is that the head wind has a value of 50 km.

Thus all the elements of the trajectory sought are known; it remains only to read on the chart which firing angle is suitable to cause the bomb to fall on the given object, in view of the given elements.

Let us observe the application of this method to bombardment by means of the Goerz range-finder and its chart.




Figs. 4, 5, 6. Direction of aim in the finder

*Application.*—The finder is under the control of the forward gunner. The bomb releaser, in reach of his right hand, is worked by pressing on levers which liberate the bombs by means of flexible controls (Fig. 8).

Several minutes before arriving over the object to be bombarded it is necessary to acquire a knowledge of two elements which will enable the gunner to read on the chart the proper firing angle. The altitude range on the barometer less the altitude of the object gives the height of fall of the projectile.

To obtain the second element which will give a knowledge of all the values of speeds we have recourse to the method of previous range finding of the ground, explained previously.

The index of the graduated disk is fixed at 22° 30′. The range of any point whatever on the ground forward of the avion is found—a route perpendicular to the one followed, a river, a house, the edge of a wood. This point is caught in the cirlce formed by the air bubble and followed while turning the disk until the index falls into the notch at the dead point; at this instant the seconds chronograph is released and the terrestrial point continues to be followed in the range finder until the 0° of the disk is checked at the dead point, the chronograph, immediately stopped, gives a number of seconds

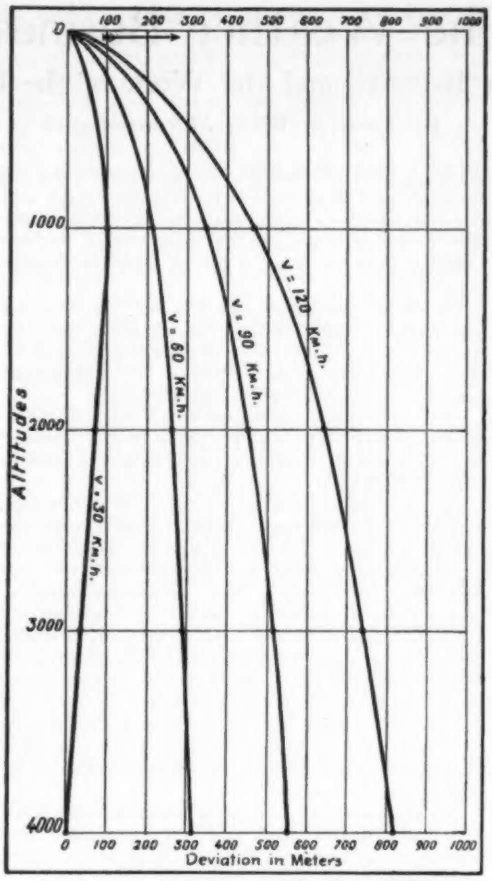



Fig. 7. The falling curves of bombs at different speeds

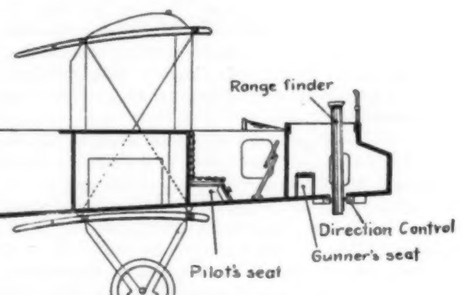



Fig 8. Location of the finder upon an aeroplane

which, when found upon the chart in the line of altitude indicates the speed of the avion with respect to the ground and the sighting angle to make use of, for example, 10°.

The index is immediately set at the number of degrees of the sighting angle, *i.e.*, 10°. The observer is ready to operate. About 2 or 3 km. before flying over the object the latter is caught in the field of vision, then in the circle of the bubble. At this instant the route corrector operates and the galvanometer indicates to the pilot whether he is following a route which will make the avion pass directly above the object.

At the precise moment when the index fixed at the number of degrees of the sighting angle falls into the notch at the dead point, *i.e.*, at the moment when the finder aims with an angle of 10° the bombardier operates the bomb releaser and the bombs fall towards the object.

Throughout the whole bombardment the pilot must keep his craft strictly head on to the wind, the air bubble

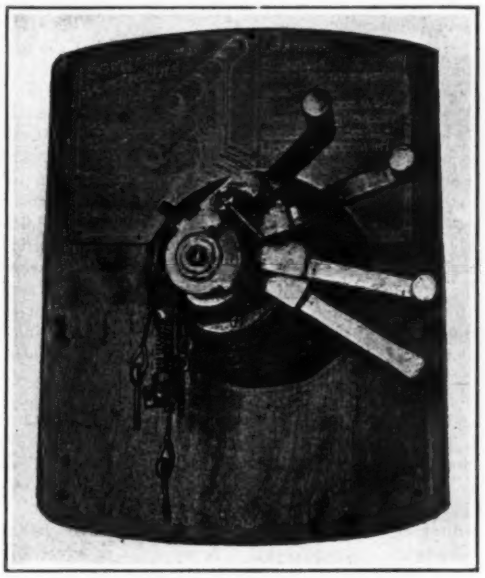


Fig. 9. Device for releasing bombs

must be kept rigorously in the center of the ocular, the play of the prism alone serving to seek the object.

This Georz range-finder is of an elementary simplicity for any one who has manipulated it in a few brisk actions. Its movable prism enables the object to be found with ease, its annular bubble permits it to be immediately centered in the vertical position. Marvelously constructed it appearas to show marked progress over all previously made range-finders.

It eliminates errors except from new and practically incalculable elements, such as variations of forces and directions of the wind between the altitude at which the sighting is done and the ground, or when it becomes impossible to keep the avion head on toward the wind. The aim being at times scientifically perfect as the application of a method derived from calculations, does it follow that the bombs will fall directly upon the objects aimed at? Results loudly proclaim a negative. Hundreds of bombs discharged on railway stations, on famous iron-works, on important aviation terrains, have been without result except for a few shell "funnels" in the ballasts, a few laborers killed, some holes in hangars. Range finding is a delicate task to execute in an avion surrounded by bursting shells.

## Note on the Oxy-Ammonia Flame

By D. L. Hammick

The fact that ammonia gas will interact with oxygen, producing a flame, has long been known. Thus Hofmann (*Ann.*, 1860, cxv., 285) describes a lecture experiment in which a stream of oxygen charged with ammonia is burnt at a jet. Hofmann's experiment was modified by Heintz (*Ann.*, 1864, cxxx., 102), who introduced oxygen, saturated with ammonia by bubbling through a strong aqueous solution, into the interior of a Bunsen gas flame. On turning off the supply of coal-gas the ammonia continued to burn.

Kraut (*Ann.*, 1865, cxxxvi., 69; see also *Ber.*, 1887, xx., 1113) made use of the catalytic effect of platinum and palladium to ignite a mixture of ammonia and oxygen. He succeeded in getting oxygen to burn beneath the surface of a strong ammonia solution.

Lupton (*Chemical News*, 1878, xxxvii., 227) describes experiments very similar to Kraut's, and, like the latter, used a platinum spiral to ignite his oxy-ammonia mixtures.

Hodgkinson and Lowndes (*Chemical News*, 1888, lviii., 27) used a platinum jet to introduce oxygen into a flask containing strong ammonia solution. The jet was fixed about 1 cm. from the liquid surface, and the mixture issuing from the neck of the flask ignited, whereupon the oxygen burnt at the jet. They found that at certain pressures fumes of ammonium nitrite and nitrate were produced, as might be expected from the fact of the platinum jet.

The writer has found that an oxy-ammonia flame can readily be produced by leading ammonia and oxygen into the appropriate inlets of any ordinary blowpipe burner and igniting the mixture that comes from the jet. With a small oxygen supply the characteristic "peach-colored" flame is obtained. On increasing the pressure of oxygen a livid white central cone, surrounded by an outer sheath of pale "peach-colored luminescence," is produced.

As well as ordinary brass blowpipes, jets contrived of nickel and of silica were used. The oxy-ammonia flame was allowed to play on a water surface or on ice. In all cases nitrate and nitrite were readily detected in solution. In no case was the presence of hydrogen peroxide indicated.

It would thus appear that the reaction between oxygen and ammonia, that is so prominent in the presence of platinum and similar metals, occurs also to some extent when metals are entirely absent.

It may be noted that some text-books (*e.g.*, Roscoe and Schorlemmer, Shenstone, etc.), either state or imply that nitric acid is produced in the oxy-ammonia flame. No references to experiments are given, however, and seeing that, as far as the writer has been able to ascertain Hodgkinson and Lownde's paper (*loc. cit.*) contains the only reference in the literature to the production of nitrates and nitrites in the flame, it would seem that the text-book statements rest solely on experiments with the oxy-ammonia flame in the presence of platinum.—*The Chemical News.*

## Prevention of Infection from Wounds

As a first-aid dressing for wounds, particularly those caused by shell splinters, a mixture of calcium hypochlorite, 10, and boric acid, 90 parts, was found to be the most efficient; it should be dusted over the surface of the wound, and does not produce any unpleasant sensation. It acts as a preventive against gangrene and also has a haemostatic action, due to the presence of calcium chloride in the mixture. Of other substances examined iodoform, ferrous sulpahte, boarx, boric acid, potassium permanganate, zinc chloride, and sodium formate were not sufficiently active to destroy the more resistant bacteria; copper sulfate and sodium fluoride were found to be effective, but their use is not recommended on account of their toxic properties.—Note in *Journal of the Society Chemical Industry*, on an articie by H. Vincent, in *Comptes Rendus*.

# The Weather Business*

## A History of Weather Records, and the Work of the U. S. Weather Bureau

By Geo. S. Bliss, Meterorologist

THE duties of the U. S. Weather Bureau are threefold: First, the forcasting of all atmospheric conditions and disturbances; second, recording the values of the several elements, and the collection, compilation, and publication of the data; third, studying the effects of weather conditions on the many and varied industries of the country and working out the problems that arise in that connection.

Meteorologists the world over recognize that the only consistent and logical basis for the making of weather forecasts lies in the taking of frequent atmospheric surveys over large areas. It is at present impossible for any other country to map quickly and thoroughly so large an area as the United States. The favorable conditions and complete facilities for such work in this country make it expedient to maintain a comprehensive weather service such as can be found in no other country in the world. The complete network of telegraph lines makes it possible to establish reporting stations wherever they are needed for the work, and the centralized management of such a vast system of lines favors an extremely rapid collection and distribution of the information. It is chiefly for these reasons that weather forecasting has reached its highest attainment in this country, and it is such facilities that enable us to collect and distribute the information in time to be of value.

The advantages of mapping large areas can readily be understood when we consider that storms from Texas or the upper Mississippi valley frequently spread over the middle Atlantic states within 24 to 36 hours. It will also be understood that the mapping of the British Isles could scarcely reveal changes much in advance of those heralded by local signs, although the map data would afford the better basis for the estimating of values.

In the matter of weather studies, and in the application of their knowledge, thus gained, to their industries, some of the European countries have made remarkable progress, and are not to be outdone by our own country.

### HISTORICAL SKETCHES

It is, of course, impracticable to give an extended discussion of the historical side of the subject in an article of this kind, and I have therefore selected a few landmarks from a chronological outline of the "History of Meteorology in the United States," as prepared by the late Cleveland Abbe.

"So far as known, the first regular record of the weather on the American Continent was kept by the Rev. John Campanius at the Swedes Fort, near Wilmington, Del., from 1644 to 1645, inclusive."

There are many old diary accounts of unusual conditions that impressed themselves upon their authors at the time, and these serve chiefly as interesting items for reading, inasmuch as they are not specific enough in most instances to afford a basis for comparison with extreme and unusual occurrences of later times. The next record of daily observations seem to have been kept at Boston at a much later date than that mentioned above.

"1729–1730. A regular weather record was kept at Boston, by Hon. Paul Dudley, Chief Justice of Massachsetts."

From this time on there were several series of records kept at various places that, on the whole, were sufficient to show that average conditions in those times were not materially different from those of recent years.

"1738–1750. Regular meteorological observations were made at Charleston, S. C., by Dr. John Lining. These included Fahrenheit and other thermometers, the barometer, and the hygroscope."

"1742–1778. Regular meteorological records were kept at Cambridge, Mass., by Prof. John Winthrop, of Harvard College. He used a Hawksbee thermometer until 1763, and then a Fahrenheit."

"1748. Meteorological records were kept by John Bartram at his botanical gardens on the Schuylkill, near Philadelphia."

"1750–1759. Dr. Chalmers, at Charleston, S. C., continued the records begun by Dr. Lining."

"1753–1755. Meteorological records were kept by Dr. Richard Brooke, near Baltimore, Md."

"1772–1777. Thomas Jefferson, at Monticello, Va., and James Madison, at Williamsburg, Va., maintained a series of contemporaneous observations and showed that the climatic peculiarities of those two places harmonized completely."

After the close of the Revolutionary War meteorological records became more common and plentiful in the Atlantic states, and in 1819 the Surgeon General of the U. S. Army established a system of observations at the army posts in all parts of the country. Many persons and institutions began records almost simultaneously with those of the army, and thus, from 1820 on, we have sufficient data for quite a critical study of climatic conditions.

The longest continuous record in the United States was begun in August, 1812, at New Bedford, Mass., by Samuel Rodman, and is still maintained by his descendants. The Pennsylvania Hospital at Philadelphia has kept a continuous record since 1824.

So far as known, the longest record by a single individual is that of Dr. Jesse C. Greene, of West Chester, Pa. He began his record in January, 1855, and has continued it to date.

The early development of the science of meteorology presents many interesting incidents. Abbe says that the first person to suspect the progressive movement of our storms as a whole was Benjamin Franklin. In September, 1743, while he was Postmaster-General, at Philadelphia, he desired to observe an eclipse of the moon, but was prevented from doing so by a storm, commonly known as a "northeaster." He later learned from Boston that the eclipse was over an hour before the storm began. From this he reasoned that, although the wind was blowing from the northeast in Philadelphia at the time, the storm formation moved up as a whole from the south or southwest. He did not live to see his theory verified or proved.

The first person to accomplish anything worth while in meteorological research, and in the scientific classification of the meteorological knowledge of the times, seems to have been James P. Espy.

"1820. James P. Espy (born 1785, died 1860) left his position in the Academy in Cumberland, Md., becoming Professor of Languages at The Franklin Institute in Philadelphia, and began his lifelong work in meteorology."

"1830. Espy announced the cooling of ascending air by expansion. About this time he resigned from all his work as a teacher and devoted himself to lecturing on meteorology."

"1836. Espy secured the appointment, by the American Philosophical Society and The Franklin Institute, of a joint committee for the study of storms."

"1840. In August and September, Espy appeared before the British Association for the Advancement of Science at Glasgow and the Academy of Science at Paris to expound and defend his ideas as to the theory and cause of storms. A committee of the Paris Academy of Sciences reported favorably on his theory of storms."

"1842. Espy was appointed 'Meteorologist to the U. S. Government' by Congress and assigned to duty under the Surgeon General of the Army, and was so employed from August, 1842, to June 30, 1847."

William C. Redfield and Elias Loomis were also early pioneers in the development of the science and contributed much of value.

"1831. Redfield published the first of a long series of memoirs of importance on hurricanes as great revolving storms."

"1836. Elias Loomis compiled his memoir on 'The Storm of 1836,' the first of a long series of important memoirs."

"1841. Loomis published his map and study of the storm of December, 1836, in the *Transcations of the American Philosophical Society at Philadelphia.*"

"1847. December 8th, Joseph Henry submitted his program of Organization and Work for the Smithsonian Institution, including, first of all, a system for extended meteorological observations for solving the problem of American storms. The Smithsonian Institution continued after this date a prominent factor in the development of meteorology in the United States."

"1854. Prof. Joseph Henry reported that the telegraph companies were furnishing the Smithsonian Institution with daily morning weather reports. He had suggested the custom, which became established, in accordance with which the first message each morning on opening any telegraph office was in answer to the salutation, 'Good morning, what is the weather?' Each local operator gave to his division superintendent and the local newspapers a statement of these weather reports, viz., temperature, wind, and weather, and all of them were telegraphed to the Smithsonian Institution, where they were exhibited on a large wall map, day after day, during the years 1854–1861. These reports were frequently used by Professor Henry to predict, or show the possibility of predicting, storms and weather, a matter that he frequently urged on Congress. Espy and Henry were the prime movers in all matters of storm prediction, both in this country and in Europe."

"1869. September 1st. Telegraphic reports and 'Weather Probabilities' began under the auspices of the Cincinnati Chamber of Commerce; 'The Weather Bulletin of the Cincinnati Observatory' began, and maps and bulletins were also published in the daily papers of Cincinnati. In November of the same year Prof. Increase Allen Lapham and Hon. H. E. Paine, of the Milwaukee Board of Trade, united with William Hooper and John A. Gano, of the Cincinnati Chamber of Commerce, in securing a resolution by the National Board of Trade, then meeting in Richmond, Va., asking Congress to establish a storm-warning service for all lake ports and sea ports."

"1870. February 2d. Mr. Armstrong, local manager of the Western Union Telegraph Company, added a manifold weather map to the previous manifold weather bulletin issued at Cincinnati; and these continued until November 10th, 1870, when the daily weather map of the U. S. Signal Service began."

"1871. The regular published weather predictions began February 19th, 1871; they were called 'Probabilities,' and were made three times daily for such elements and periods in advance as seemed warranted by the maps, and for eight geographical districts, viz., New England, Middle States, South Atlantic States, Lower Lakes, Upper Lakes, Eastern Gulf, Western Gulf, and the Northwest. Beginning with May, 1886, predictions have been made for states and parts of states instead of districts. Since July, 1888, the morning forecasts have been for periods 36 hours in advance, and beginning August 1, 1898, evening forecasts have been made regularly for periods 48 hours in advance."

"1890. October 1. The act transferring the meteorological work of the Signal Service to the Weather Bureau of the Department of Agriculture was enacted. This act went into effect July 1, 1891."

### WEATHER FORECASTING

There is an old saying that "Poets are born and not made," and the same sentiment can be applied quite appropriately to weather forecasters. The most profound students of atmospheric physics, or, in other words, the greatest meteorologists that the world has produced, were far from being the best forecasters. It is possible, of course, to attain to a certain degree of proficiency in forcasting by a diligent study of the science of meteorology, but in order to excel in the profession one must possess a special faculty for intuitively and quickly weighing the forces indicated on the weather map and calculating the resultant. This special faculty is developed by long and continued study and association with the maps, rather than by a profound study of atmospheric physics, but it is impossible to develop it to the same degree in all individuals. It goes without saying that the forecaster must be a meteorologist. He must be so familiar with the underlying principles of the science that he can readily comprehend the significance of the forces that he sees represented on the map; but it is not necessary that he should be able to work out complicated mathematical problems in the mechanics of the atmosphere.

One must pass a rigid civil service examination in meteorology, physics, and mathematics for admission to service in the Weather Bureau. It usually requires from five to seven years in actual service to develop the ability required for a local forecaster, while a considerable number are never able to qualify, and only about two per cent of those who enter the service are ever able to qualify as district forecasters. The difference in the requirements of the two grades is a matter of 4 or 5 per cent in actual verification.

District forcasters are located at Washington, Chicago, New Orleans, Denver, San Francisco, and Portland, Ore. It is their duty to issue all storm, cold wave, and frost warnings, and to make daily forecasts of prevailing conditions for each state, such as are circulated by the Associated Press. The local forcaster is expected to study the local influences which sometimes cause different conditions than those prevailing for the state as a whole. He must modify and amplify the forecast for his city and vicinity accordingly, and must include specific items, such as night minimum temperatures in winter, and other information when practicable. Sometimes he must differ with the district forecaster, and in this he is not restricted, except that the result of his efforts as a whole must be to improve the forecasts. Every published forecast is compared

*Journal of the Engineer's Club of Philadelphia.

with the weather and temperature conditions that follow, and is made a matter of record in the Verifying Division of the Central Office in Washington.

The average success of all forecasts, for all seasons and for all parts of the country, is not far from 85 per cent. This high degree of accuracy is not generally realized, because many people receive their impressions of the service from the occasional failures that are brought to their notice. Again, when the average citizen is asked his opinion of the weather prospects for the day or night, he can only guess, because he has no information upon which to do otherwise. Unless he is a well-trained and thinking man, it is natural that he should conclude that all weather forcasts are mere guesses. The fact is that there are comparatively few things in which we can look into the immediate future with the assurance that obtains in weather forecasting.

The impression is largely prevalent that the making of the daily forecasts is the chief function of the Bureau, while in reality it is among the least valuable features of its work. The daily forecasts are constantly in the limelight, and they are the only portion of the work that reaches the whole people, but in the final analysis they are chiefly matters of convenience rather than of life or death or of the saving or loss of property. They are the most difficult part of the forecaster's work, for the reason that they are verified by the conditions that obtain during definite 12-hour periods, from 8.00 A. M. to 8.00 P. M. and from 8.00 P. M. to 8.00 A. M.

If a severe storm is moving up our Atlantic coast and warnings are ordered to be displayed from Jacksonville, Fla., to Eastport, Me., it matters not if the time of transition covers 36 hours or 48 hours, inasmuch as it is unsafe for vessels to leave port until it has passed. When a cold wave is sweeping across the country and warnings are distributed broadcast on its advance, it matters not if the lowest temperature at any particular place shall be reached in 24 hours or in 36 hours, inasmuch as perishable goods must be protected until a reaction to warmer has set in. Thus it will be understood that the really valuable part of the forecaster's work requires less precision in some respects than do the daily forecasts, in order to become wholly efficient and effective.

#### ACTIVITIES OF THE WEATHER BUREAU

If we were to express, in terms of dollars, the value of each of the several lines of the Bureau's work, their relative worth would probably come in the following order: Storm warnings; cold wave warnings; special shipper's forecasts; climatological service; river and flood service; frost warnings; daily forecasts; crop service, and use of the records in court.

We cannot really calculate the value of the storm warnings, because we do not know what the losses would be in each instance if the warnings had not been displayed, for in these latter days severe storms do not sweep our coasts or our Great Lakes unheralded, in order to furnish examples. We can only estimate the probable results from those that obtained before the storm warning service was organized, when a single storm would sometimes claim more than a score of vessels, with their cargoes. Tropical storms are dangerous for vessels of all classes, but the large, high-power steamers are able to ride out almost any storm in northern latitudes, providing they are out on the open sea. The storm warnings are therefore of chief value to the medium-sized and smaller vessels, such as are engaged in coastwise trade.

In the middle Atlantic states a whole winter season will sometimes pass without a severe cold wave, but in the Middle West and the great central valleys they are of more frequent occurrence. A cold wave warning, when spread over the great central states, is followed by measures to protect immense quantities of perishable goods. A few thousands of dollars' worth in this town and a few thousands at another place mean that it runs into the millions when it is summed up for such a vast territory.

The special shipper's forecasts are of chief value in the larger cities where great quantities of perishable goods are prepared for shipment. They consist of advice regarding the temperatures that will be encountered by shipments going out in various directions, in order that the goods may receive proper protection in the packing or that certain shipments may be held up a day or two as the conditions may require. Wherever this service has been properly administered it has resulted in saving about 10 per cent of all perishable goods handled during the winter season, and the losses have been comparatively unimportant. When one considers the millions of dollars' worth of goods that are handled in our large cities during a winter season it will be understood that a saving of 10 per cent, which was formerly lost by freezing, represents a very large sum.

The climatological service consists of the collection, compilation, and publication of all of the weather rcords made in the whole country. They comprise not only the detailed records from the 200 regular Weather Bureau stations, but also the less comprehensive ones from something over 4,500 coöperative stations. The latter stations are equipped with standard maximum and minimum thermometers and rain gages, and daily readings of the instruments are made. There are one or more coöperative stations in nearly every county, and it will be seen that the climatological survey is very thorough and complete. These data have come to be used so largely that if the Bureau were to render no other service it would justify its existence at the present cost of maintenance, which is about $1,700,000 per annum, or 1.7 cents per capita for the people of the United States.

The river and flood service furnishes daily gage readings at many points on the larger streams, and at one or more places on each of the smaller rivers. For example, there are nine gaging stations on the Delaware and its tributaries, although it is an unimportant stream, from a flood service point of view. The daily forecasts of the river stages are valuable in some places in the movement of river traffic, while the flood warnings result in the saving of much movable property every year. In some places, such as the Ohio River below Cincinnati and the Mississippi below St. Louis, the movements of a flood can be calculated with mathematical precision. For example: it takes nearly four weeks for the crest of a flood to move from St. Louis to New Orleans, and yet as soon as it has passed St. Louis it is possible to forecast the stages that will be reached at the various gages below to within from 0.2 to 0.4 foot, and to estimate the time of arrival of the crest of each place within from two to four hours. In the smaller streams and near the headwaters of the larger streams the work is much more complicated and much less accurate.

The frost warnings are becoming more and more valuable from year to year, as the farmers and fruit raisers are learning better and better how to take protective measures when the warnings are received. They are of chief value to orchardists and fruit raisers generally, and to truck growers in some parts of the country. The successful growing of cranberries is very largely dependent upon the frost warning service.

## The Structure of Matter*

SINCE Professor Bragg lectured before the Institute of Metals on X-rays and crystal structure,[1] a year ago, further striking developments have become known of X-ray studies, not only of crystals, but also of amorphous substances, liquid crystals, liquids and gases. The dimensions of the hydrogen molecule and of the benzene ring have been deduced, and it seems possible to determine the number and grouping of the electrons in the atom. In his original experiments of 1912 M. von Laue was guided by the consideration that the grouping of the atoms in crystals should act like a natural grating, sufficiently fine to produce a diffraction of Röntgen rays, not realizable so far with artificial gratings. He passed a beam of rays normally through a crystal on to a photographic plate; the resulting diagram showed dark spots arranged in circles passing through the central spot, and the intensities and positions of the spots allowed of drawing conclusions as to the grouping of the atoms in the crystal. Modifying the method, Professor Bragg and his son made a beam of homogeneous X-rays fall obliquely on a crystal; the successive parallel planes, in which the atoms are supposed to be arranged in the crystal, reflected the rays at certain angles, and from the interferences and ionizations produced either the spacings of the planes or the wave-length of the rays were deduced. Both the methods are used, and give, on the whole, concordant results; the Bragg method seems the more convenient and less difficult of interpretation; but it appears restricted to the examination of crystals.

Working with Laue, Friedrich and Knipping also obtained certain results with fine powders of crystals. Taking up this line of research, P. Debye, of Amsterdam, and P. Scherrer argued that the regularity of the grouping of the electrons should remain recognizable even in irregular masses of powders. Homgeneous X-ray illumination would excite a secondary radiation, which would not be uniformly radiated into space, but show maxima and minima lying on cones, the axes of which would coincide with the direction of the primary ray. When starting with crystals the effects of this grouping of the electrons would be complicated by the interference due to the orderly arrangement of the atoms. Experimenting with amorphous substances and powdered crystals, Debye and Scherrer pressed the material into cylindrical rods, 2 mm. in diameter, 10 mm. long, and placed the rod in the middle of a cylindrical camera; the X-ray beam fell through a bore of 2.5 mm. in a block of lead on the cylinder and was reflected on to curved films. To secure cohesion the cylinder of powder was coated with collodion. The photographs obtained look like spectra, the lines of which are straight in the central portion, but become more and more curved on both sides; they may also be likened to the pattern produced when polarized light traverses a biaxial crystal. In some lines black specks can be distinguished; this was noticed in the case of amorphous silicon, and is ascribed to the presence in the powder of small crystals which happened to lie properly orientated to reflect the primary rays from the copper anticathode. From the measurements the length of the elementary cube was calculated: silicon, 5.46; graphite, 4.69; lithium fluoride, 4.14, all multiplied by $10^{-8}$ cm.; the shortest distance apart of two silicon atoms was estimated at $2.33 \times 10^{-8}$ cm.

Debye and Scherrer conducted similar experiments on gases and liquids at Munich and Göttingen; particulars of this method are not available. Accepting Bohr's hydrogen molecule, however, as consisting of two atoms at the ends of a polar axis and two electrons moving diametrically to one another on a circle equatorial to the axis, they calculated that the distance between the two atoms is 0.604 and the diameter of the equatorial circle $1.05 \times 10^{-8}$ cm., and that the electrons describe $7 \times 10^{15}$ revolutions per second. The benzene molecule $C_6H_6$ is supposed to consist of six groups of CH at the corners of a hexagon (the benzene ring); the diameter of this ring is estimated at $12.4 \times 10^{-8}$ cm., a side at $6.2 \times 10^{-8}$ and its thickness at the most at $1.9 \times 10^{-8}$ cm. From the molecular refractivity and dispersion, on the other hand, L. Silberstein, of Rome (*Philosoph. Magazine*, February, 1917), calculates the distances between the atoms in the molecules of hydrogen, oxygen and nitrogen at 1.067, 1.265 and $1.493 \times 10^{-8}$ cm., and that the number of dispersive electrons is in each case that of the normal valency. The dimensions agree with those deduced from the kinetic theory of gases.

Building on these and on similar researches, and upon J. Stark's dynamics of the atom, F. Rinne (Leipzig), in his leptonology (or study of the fine structure of matter), shows that the different forms of matter, gas, liquid, liquid crystals, crystals, form a continuous series. Not a very novel conclusion, it may be objected; but it is based upon reasoning which only the recent researches justify and upon somewhat successful attempts (M. Born) to deduce the properties of solids from their atomic grouping. The crystalline state, it is suggested, is characterized by a three-dimensional, periodic and straight-line orientation of equal particles, combined with a capability of indefinite extension of the periodic structure. This latter capability is ascribed to residual valencies in the surface layers (Huber and Panetti), and it is owing to them that certain isotopes fall out together (Fajans and Richter). In amorphous solids, which are least understood, though distinguishable from crystalline matter by X-rays, this extension capability is missing. It persists to a certain extent, however, in the liquid crystals of O. Lehmann, which arrange themselves in lines parallel to the principal molecular axis under the influence of internal forces—external forces of the magnetic field, *e. g.*, do the same in the case of nitrobenzene, for instance—while the particles retain the mobility of liquids to some degree. The ring structure of true liquids like benzene, and still more the tetragonal structure of tetramethylene leads over from amorphous liquids to liquid crystals. Even amorphous gases like hydrogen are not devoid of orderly structure; though not of a three-dimensional periodicity, they conform to geometrical rules.

*From *Engineering*.

[1]See *Engineering*, June 2, 1916, page 518.

## Alloys for Small Castings

THERE is probably no department in metal working in which research is more greatly needed than in that concerned with the composition of alloys for small and delicate castings. It is true that for typefounding purposes a wide range of the alloys of lead and antimony is available, while those of copper and zinc used for the different descriptions of brass have received careful attention; but a light and tough metal, such as could be employed with advantage for screwed connections for gas and water pipes and for many electrical fittings, is much needed. Aluminium is still a somewhat new metal for industrial purposes, and though the alloys of copper and aluminium, in the nature of aluminium bronze, have been the subject of much study on the Continent, more especially for castings suitable for the motor trade, a really reliable combination of these metals for general use has yet to be discovered. Some excellent small machines for casting under pressure have been introduced, capable of producing from type metal and alloys of its class where the melting point is low, useful and valuable castings, but most of these alloys are too brittle for general use, or in another direction are too soft to stand a fair amount of wear. In cases where the melting point is high and where rapid casting is essential, devices for the water-cooling of the metal mold generally entail difficulties in manipulation.—Engineering Supplement of the London *Times*.

## The Estimation of Toluene in Crude Petroleum

Since the war began the public has heard a great deal about benzene and toluene and aromatic hydrocarbons. In normal times these products were chiefly wanted in the dye industry, as solvents, and as motor fuels, but the claims of the manufacturers of high explosives are now paramount, and the public must put up with a severely restricted supply of motor spirit. As raw materials for high explosives the various aromatic hydrocarbons have not equal values; but they are all needed in the many departments of the industry. The three chief aromatic hydrocarbons—the name is due to the peculiar aromatic smell of many of their derivatives—are benzene, toluene and xylene; inasmuch as benzene had a long history of varied application, and toluene is the chief raw material for the manufacture of one of the most powerful modern explosives—trinitrotoluene, the popular TNT—the term toluene now frequently serves as a general name for raw materials for explosive from that group. Benzene is $C_6H_6$, toluene $C_6H_5.CH_3$, xylene $C_6H_4\ (CH_3)_2$; they are all colorless liquids, of densities 0.884, 0.870, 0.865. This last figure is approximately correct for the three isomeric xylenes, the ortho-, meta- and para-xylene, which generally occur together, the meta compound predominating strongly in coal-tar. Xylene, we should say, is almost as valuable at present as toluene and costs more than twice as much as benzene. The boiling points are: benzene 80.5, toluene 110.3, and the three xylenes 141 deg., 137.8 deg., 147 deg. C.

These hydrocarbons and their higher homologues, together with the saturated hydrocarbons or paraffins of the formula $C_nH_{2n+2}$, the unsaturated carbons or olefines $C_nH_{2n}$, are found in natural petroleum; but the aromatics often do not make up 1 per cent of the crude oil. American petroleum is very poor in toluene, but richer in higher aromatics, especially when asphaltic; Trinidad oil may contain several per cent of toluene and more of xylene and the higher homologues. As a rule the direct distillation of the crude oils for toluene would not pay, in spite of the above-mentioned differences in boiling-points, even if there were no paraffins, etc., present of almost the same boiling-points, and if the aromatics had not the unfortunate tendency of forming mixtures with other hydrocarbons, alcohols, etc., which pass over as such when heated at temperatures far below the real boiling-points. Hence the desire to raise the percentage of toluene by cracking. But all cracking processes are wasteful; a large bulk of a useful oil is turned into carbon, methane, hydrogen and unsaturated hydrocarbons, all inferior in value to the main product aimed at. There is doubt, moreover, as to the percentage of toluene actually gained by cracking; the analyses are difficult, and reliance is often placed on indirect estimates. Attention is therefore once more drawn to the direct isolation of toluene from the crude oil or spirit. Such processes would have the great advantage that they would not—or should not—impair the remaining oil. On account of the presence of the paraffins in the original oil, however, the analytical difficulties are, in some respects, even greater than with cracked oil. Before risking novel processes, moreover, manufacturers want to have precise information on the percentage of toluene that might be extracted from crude oils and petroleum spirits. It was with these analytical problems that Mr. S. E. Bowrey, B.Sc., London, dealt in an able paper on "The Estimation of Toluene in Crude Petroleum," brought before the Institution of Petroleum Technologists. The paper was almost purely chemical; but an outline may be of interest.

When a crude oil is examined, everything that will boil away above 150 deg. C. (about) is, as a rule, first removed by distillation. Then follows treatment with sulfuric acid and washing with alkali and water; the acid binds the unsaturated hydro-carbons, but not the others. The specific gravity of the residue generally affords useful information. Often, however, sulfonation has to follow, treatment with concentrated and then with fuming sulfuric acid, which attack only the aromatic compounds, or nitration (treatment with nitro-sulfuric acid), and further various selective solvents are used, among which Edeleanu's method (liquid sulfur dioxide) stands foremost. Mr. Bowrey's method is an improvement of that of Edeleanu, who first proposed it for the raffination of lamp oil, not for the laboratory. None of these reagents are very pleasant to deal with. Mr. Bowrey hence tried, first of all also the apparently simplest method of splitting the petroleum, by careful redistillation, into separate fractions for benzene, toluene and xylene. That this is possible was stated by Dr. A. E. Dunstan, who, following Professor Brame, made a valuable contribution to the discussion; but he had to apply six redistillations. In general, the already mentioned tendency of the aromatic hydrocarbons to form with paraffin mixtures of constant boiling-points interferes too much; these difficulties, Mr. Bowrey stated had been experienced also in a 10-ton plant in Trinidad. We will say a few words about these different methods.

Density determinations should be helpful, because the paraffins are lighter than the aromatics and the naphthenes; but the aromatics themselves differ little in density, while the praffins differ considerably, so that the method is promising only when relative significant percentages of aromatics are present, and there is a complication, because it is not certain that the various constituents really mix, as is assumed, without change of volume. Nitration may go further than intended, and lead to a general oxidation, and as mono-, di- and tri-products may be formed, the calculations are not easy; as regards sulfonation, the quantitative recovery of the sulfonic acids (by hydrolysis) is impracticable. These reasons explain the preference for selective solvents of less violent type than those acids. Such are alcohols, acetone, aniline and sulfur dioxide; all these dissolve the aromatics rather than the paraffin and naphthene. Dr. Mollwo Perkin remarked that he had tried dimethyl sulfate before the sulfur dioxide was introduced; it had the advantage that it could be used at ordinary temperatures, but it was very poisonous; that, however, seems to be an individual question, since Dr. Dunstan had not been troubled by the poisonous character of this compound.

The liquid sulfur dioxide $SO_2$ is, of course, a refrigerating agent, and one of Mr. Bowrey's improvements, as we shall see, consists in the utilization of this property, instead of placing the liquid in a vessel cooled by ice and salt. Thus he was able to work at −35 deg. C. (instead of −12 deg.) and to increase the percentage of aromatics (he mostly experimented with mixtures of the three in equal proportions) extracted from paraffin (85 per cent) mixtures considerably. He extracted first in a Dewar vessel, joined to a pump so that distillation took place in a vacuum; more benzene than xylene is extracted as might be expected; but as some paraffins are also volatilized, some correction has to be applied. Dr. Dunstan subsequently pointed out that as the process really depends upon differences in solubility and volatility a careful study of temperature influences is required. Mr. Bowrey's improved apparatus, which was much praised both for its ingenious design and as a fine piece of glass-blowing, consists of a three-walled Dewar flask joined to a pump and thereby to a distilling flask, in which the extract is freed from the $SO_2$ by heating over a gas flame, while the pump and a separating funnel had been used in his first apparatus. The inner jacket of the Dewar flask is charged with liquid $SO_2$ to keep the liquid inside cold.

The chief novelty, however, is the automatic temperature regulator of the Reichert type which he has added to his distillation apparatus. It is a rather complicated device. The quantity of extract obtained is generally small, and the fractionation of the isolated hydrocarbons (into benzene, toluene and xylene) has to be slow, at the rate of about six drops per minute. An apparatus for this purpose would require very careful watching; the apparatus Mr. Bowrey has designed can be left to itself. In the stopper of the flask is fixed a dephlegmator, a vertical glass tube or column loosely packed with copper turnings and surrounded by a jacket in which $SO_2$ is circulating under reduced, adjustable pressure. The vapor leaves the column above through a pin-hole aperture, and the vapor pressure in the column is kept constant by the action of a mercury cut-off. This device consists of a short U-tube filled with mercury and sealed into the column below the pin-hole. When the vapor pressure falls the mercury recedes and admits gas from the rubber tube joined to the U outside the column; the increase of gas-feed makes the flame under the flask shoot up, and the flask gets hotter. Then the vapor pressure rises in the column, and the gas inlet is closed again. Thus the gas-feed may be adjusted within wide limits, from 30 drops down to 6 and fewer per minute. The gas which is not burnt has to be provided with an outlet, as the action of the regulator depends upon the gas pressure in the main, and this gas escapes through a bottle containing spindle oil; the escaping gas is burnt, a pilot flame being kept alight for this purpose. Thus there is a slight waste of gas; but the apparatus worked well.

The figures given by Mr. Bowrey were in good agreement. In a crude Trinidad oil he found thus: 0.52 per cent, 1.7 per cent and 2.27 per cent of benzene, toluene and xylene, the corresponding percentages for the spirit being 1.25, 4.11 and 5.48. Though the method is not perfect, it is preferable to others, and it was warmly welcomed.—*Engineering.*

## A Substitute for Platinum-Iridium Alloy

Owing to the scarcity and high price of iridium a recent inventor has proposed to substitute osmium in the well known platinum-iridium alloy that has been widely used for many purposes. One part of osmium has been found to give the same hardness as two parts of iridium, and the resulting alloy is ductile and is less affected by acids than platinum-iridium. Alloys with 10 per cent osmium are so hard as to be worked with difficulty, while a two per cent alloy is well suited for jewelry, as it is hard and tough, while alloys containing six to ten per cent of osmium will serve all purposes that iridium alloys of from 15 to 25 per cent of iridium for contact points in electrical apparatus. In making these alloys metals of a very high degree of purity must be used. This alloy has been patented.

## True Greenheart Not Poisonous—A Correction

In an article on the above subject in the issue of July 28th, No. 2169, the substance, lapachol, is referred to as an alkaloid. This it appears is an error, for Dr. Hooker, who is referred to, informs the writer of the article that lapachol contains no nitrogen, and has no basic properties; on the contrary, its acid properties are quite marked.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